Brent Wiley, Editor
John Kelly, Jr., Associate Editor
James D. Kelly, Advertising Mgr.

BOARD OF DIRECTORS
1935 • 1936

PRESIDENT, G. R. CARROLL, *Electrical Superintendent, Jones & Laughlin Steel Corp., Aliquippa, Pa.*

1ST VICE PRESIDENT, F. W. CRAMER, *Superintendent, Elect. Const., Republic Steel Corp., Youngstown, Ohio.*

2ND VICE PRESIDENT, J. A. CLAUSS, *Chief Engineer, Great Lakes Steel Corp., Ecorse, Mich.*

DIRECTOR AT LARGE, C. A. KRAL, *Assistant General Manager, Wheeling Steel Corp., Steubenville, Ohio.*

HONORARY DIRECTOR, J. FARRINGTON, *Electrical Superintendent, Wheeling Steel Corp., Steubenville, Ohio.*

HONORARY DIRECTOR, E. FRIEDLANDER, *Pittsburgh, Pa.*

PAST PRESIDENT, W. H. BURR, *Electrical and Mechanical Superintendent, Lukens Steel Co., Coatesville, Pa.*

PAST PRESIDENT, W. E. MILLER, *Electrical and Mechanical Superintendent, Bethlehem Steel Co., Johnstown, Pa.*

TREASURER, C. H. HUNT, *Assistant to President, Weirton Steel Co., Weirton, W. Va.*

SECRETARY, J. L. MILLER, *Assistant Chief Engineer, Carnegie-Illinois Steel Corp., Youngstown, Ohio.*

DIRECTOR, C. J. SMITH, *Superintendent of Auxiliary Departments, Carnegie-Illinois Steel Corp., S. Chicago, Ill.*

DIRECTOR, H. G. R. BENNETT, *Assistant General Superintendent, Carnegie-Illinois Steel Corp., Duquesne, Pa.*

DIRECTOR, STANLEY GRAND-GIRARD, *Mechanical and Electrical Superintendent, Sharon Steel Hoop Co., Sharon, Pa.*

DIRECTOR, C. R. TINSLEY, *Electrical and Mechanical Superintendent, United States Pipe & Foundry Co., Bessemer, Ala.*

DIRECTOR, M. J. CONWAY, *Fuel Engineer, Lukens Steel Co., Coatesville, Pa.*

DIRECTOR, C. C. PECU, *Lubrication Engineer, Bethlehem Steel Co., Lackawanna, N. Y.*

DIRECTOR, C. C. WALES, *Chief Engineer, Otis Steel Co., Cleveland, Ohio.*

DIRECTOR, L. F. COFFIN, *Superintendent Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.*

DIRECTOR, J. A. VOSS, *Manager, Industrial Relations, Republic Steel Corp., Cleveland, Ohio.*

MANAGING DIRECTOR - BRENT WILEY
Empire Building, Pittsburgh, Pennsylvania

IRON AND STEEL ENGINEER

VOL. XIII FEBRUARY • 1936 NO. II

Contents

Annealing Sheet and Strip Steel—With The Use of Electric Furnaces—by A. N. Otis, Industrial Engineering Department, General Electric Company, Schenectady, New York 1

Discussion — Annealing Sheet and Strip Steel — With The Use of Electric Furnaces—Discussion presented by M. J. Conway, H. V. Flagg and A. N. Otis 10

Open Hearth Furnaces—Factors to be Considered in Insulation—by Gilbert Soler, Director of Reserch, Timken Steel & Tube Company, Canton, Ohio 11

The Pouring of Molten Steel—Efforts Made To Produce Sound Ingots—by J. D. Walters, Open Hearth Superintendent and E. G. Hill, Director of Research, Lukens Steel Company, Coatsville, Pa. 14

Discussion—The Pouring of Molten Steel—Efforts Made to Produce Sound Ingots—Discussion presented by J. A. Carter, K. C. McCutcheon and E. G. Hill 18

Use of The Venturi Port—Its Design, Construction and Operation—by George L. Danforth, Jr., President, Open Hearth Combustion Company, Chicago, Illinois 19

Discussion—Use of The Venturi Port—Its Design, Construction and Operation—Discussion presented by J. A. Carter, G. E. Rose, and W. C. Kitto 23

Roof Temperature Control — For Use in Open Hearth Furnaces — by M. J. Bradley, Engineer, Leeds & Northrup Company, Philadelphia, Pa. 24

Discussion — Roof Temperature Control — For Use in Open Hearth Furnaces—Discussion presented by J. A. Carter, K. C. McCutcheon, L. A. Deesz, M. J. Bradley, E. W. Hill, M. J. Conway and Gilbert Soler ... 28

Items of Interest 31

Coming Meetings and Papers II

Editorial III

Index to Advertisers IV

Published Monthly by
ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS
Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879. Subscription Price $5.00 per Year. Single Copy $1.00

General view of Carnegie - Illinois hot strip mill to be inspected by the Society on April 23.

Coming Meetings and Papers

CHICAGO DISTRICT SECTION

PHIL SMIDT'S

Dinner: 6:30 P.M. Meeting: 7:30 P.M.

WEDNESDAY, MARCH 18, 1936 (TENTATIVE DATE)

"*Purchased Power versus Plant Generated Power*" by John W. Bates, Electrical Engineer, American Sheet & Tin Plate Company, Pittsburgh, Penna.

PHILADELPHIA DISTRICT SECTION

ENGINEERS CLUB, 1317 SPRUCE ST.

Dinner: 6:00 P.M. Meeting: 7:00 P.M.

SATURDAY, MARCH 7, 1936

"*Modern Lighting Technique in Steel Mills*" by Walter Sturrock, Illuminating Engineer, General Electric Company, Nela Park Engineering Dept., Nela Park, Cleveland, Ohio.

PITTSBURGH DISTRICT SECTION

WM. PENN HOTEL—BLUE ROOM

Dinner: 6:30 P.M. Meeting: 8:00 P.M.

SATURDAY, FEBRUARY 29, 1936

"*Stress Analysis in Locomotives and Other Large Axles*" by T. V. Buckwalter, Vice President, and Dr. O. J. Horger, Research Engineer, Timken Roller Bearing Company, Canton, Ohio.

SPECIAL FEATURE:—Moving pictures of the continuous hot strip and cold strip mills of the Ford Motor Company, Detroit, Mich., and the continuous strip mill of the Carnegie-Illinois Steel Corp., McDonald, Ohio. These moving pictures will be furnished through the courtesy of the Timken Roller Bearing Co.

CLEVELAND DISTRICT SECTION

FRIDAY, MARCH 6, 1936

Dinner 6:15 P.M.

SOUTHERN TAVERN, 1232 EUCLID AVE.

Meeting 8:00 P.M.

CLEVELAND ENGINEERING SOCIETY ROOMS

"*Recent Developments in Electric Wire and Cable*" by T. F. Peterson, Consulting Engineer, American Steel & Wire Co., Worcester, Mass.

BIRMINGHAM DISTRICT SECTION

THOMAS JEFFERSON HOTEL

SATURDAY, FEBRUARY 29, 1936

7:00 P.M.

"*The Problem of Motor Applications for Continuous Mill Auxiliaries*" by R. A. Geuder, Engineering Dept., Reliance Electric & Engineering Company, Cleveland, Ohio.

Spring Engineering Conference

WEDNESDAY EVENING, APRIL 22 THURSDAY—ALL DAY, APRIL 23

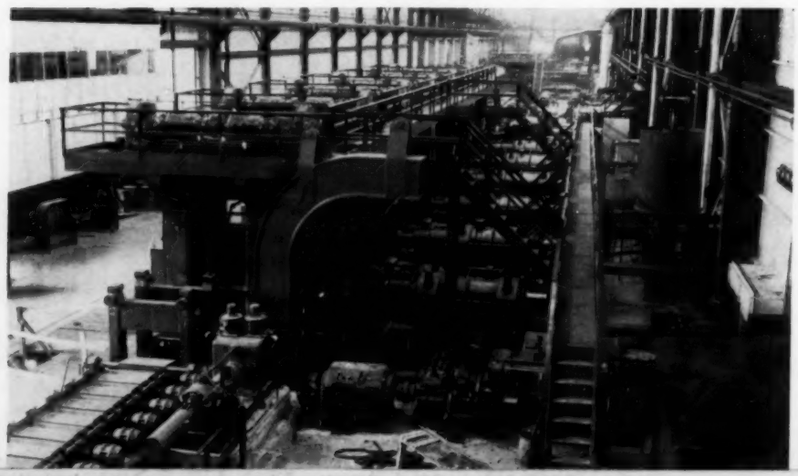
OHIO HOTEL—YOUNGSTOWN

Tentative Subjects to be Discussed: Refractories—Soaking Pits—Temperature Measurement of Moving Material—Descaling—Pickling.

INSPECTION TRIP

THURSDAY AFTERNOON

Inspection trip to 43" Continuous Hot Strip Mill, Carnegie-Illinois Steel Corporation, McDonald Mills, Youngstown, Ohio.



Another view of Carnegie - Illinois hot strip mill showing finishing train from coiler building.

Steel Progress and Our Society

THE 1935 REVIEWS of the steel industry in practically all phases of its activity including addition of mills, improvement of design and of methods of operation, etc., has been presented during the past month by the Iron and Steel Engineer and various other publications.

The main contribution to the consumer as made by the steel industry of late, with particular reference to sheet and strip mills is an improvement of quality and material, reduction in price of several kinds of products as compared with prices of a few years ago. Older methods of rolling and consequently the mill equipments used are constantly being replaced by those incorporating improved ideas which include an increase of width of product, increase of speed of rolling, improvement of quality and the gradual elimination of such disturbing factors as excessive bearing pressure, improper tension on metal between stands, undesirable variation in reductions across the strip, uncertainty of rolling temperature and other items.

In the development of these improved installations, electricity plays an important roll, starting with the main drive and extending to all phases of the rolling process. Control devices which give accuracy, and are practically instantaneous in operation, are serving as very helpful agents. In fact it can be said that during the last two decades one of the most outstanding factors in the improvement of the manufacture, rolling and treating of steel has been the application of electricity which today is practically universal in the modern plant.

The Association of Iron and Steel Electrical Engineers has as its main purpose the furthering of improved methods used in the steel industry covering electrical and other engineering phases of the work and while a great deal has already been accomplished the field for additional effective improvement is a broad one. The steel industry is better organized today than ever to accomplish these results with the broadening of their policies of combining departments and organizing generally to foster closer cooperation between departments.

The outlook for 1936, and may we predict also for 1937, gives evidence of further improvements in the steel industry along the above lines.

INDEX TO ADVERTISERS

A

The Alliance Machine Company 85
Allis-Chalmers Manufacturing Company 91
Aluminum Company of America 68

B

The Baker-Rauling Company 88
The Bantam Ball Bearing Company 58
The Bartlett-Hayward Company 72
Bussmann Manufacturing Company 34–35

C

The Clark Controller Company 87
Crocker-Wheeler Electric Manufacturing Company 66
Cutler-Hammer Inc. ..... Cover 2

E

Edison Storage Battery Company 65
The Electric Controller & Mfg. Company 60
The Electric Furnace Company 62
Electric Service Supplies Company 87
The Electric Storage Battery Company 50
Thomas A. Edison Company, Inc. 65

F

Farrel-Birmingham Company, Inc. 84

G

General Electric Company 45–78–Cover 4

H

Helwig Company 85
Hills-McCanna Company 88
Hodson Corp. 43
Hyatt Roller Bearing Company 54

I

Iron and Steel Exposition 44
I-T-E Circuit Breaker Company ..... Cover 3

J

Jefferson Electric Company 59
Johns-Manville 61

L

Leeds & Northrup Company 56–71
Lewis Foundry & Machine Company ..... Cover 1
The Lincoln Electric Company 63

M

The Martindale Electric Company 83
Mesta Machine Company 57
Metal & Thermit Company 47
Morgan Construction Company 49
Morgan Engineering Company 77

N

National Carbon Company, Inc. 76–86
National Erie Corp 89
New York & New Jersey Lubricant Company 86
The Nichols-Lintern Company 84
Norma-Hoffmann Bearings Corp. 73

O

Ohio Electric Mfg. Company 82
The Okonite Company 64

P

Pennsylvania Transformer Company 82
Poole Foundry & Machine Company 90
Pittsburgh Rolls Corporation 67
Pyle National Company 46

R

Reliance Electric & Engineering Company 48
Rockbestos Products Corp. 51
R-S Products Corporation 80

S

Schloemann Engineering Company 79
S-K-F Industries Inc. 37
B. F. Sturtevant Company 70
Surface Combustion Corp. 75

T

The Thompson Electric Company 89
The Timken Roller Bearing Company 92
The Tool Steel Gear & Pinion Company 69
Trumbull Electric Mfg. Company 55

U

Union Carbide & Carbon Company 76–86
United Engineering & Foundry Company 40

W

Wean Engineering Company 39
The Wellman Engineering Company 74
Westinghouse Electric & Mfg. Co. 52–53
Whiting Corp. 81

ANNEALING SHEET AND STRIP STEEL

WITH THE USE OF ELECTRIC FURNACES

By A. N. OTIS
Industrial Engineering Department
GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania, September 24, 25, 26, 1935

▲ THE METHODS used for annealing sheets and strip steel are being given considerable study at this time, due in part undoubtedly to the installation of numerous continuous mills for wide strip, from which sheets are cut, and the increasing proportion of cold reduced material which is made into sheet products, as distinguished from hot finished sheets.

Cold reduced material, to which the present subject matter alludes, is said to have different characteristics from hot finished material, not only in the condition of the surface and grain structure, but also in the heat treatment required to produce deep drawing properties.

It is generally, although not universally, conceded that a single heat treatment (anneal) of cold reduced material will produce required deep drawing properties, and thus eliminate the normalizing treatment usually required for hot-rolled sheets. Furthermore, if normalizing is done in existing types of fuel-fired furnaces, the material, which already has bright and smooth surfaces, is likely to be oxidized or pitted. For this material therefore, additional investment would be required in new types of normalizing furnaces.

The desirability of avoiding double treatment is obvious from a cost standpoint, although it is considered by some to better assure uniformity of physical properties.

Still others feel that a normalizing treatment only, properly controlled, offers possibilities of producing material that would be accepted, for at least a considerable portion of the requirements.

Since cold reduced material will form the bulk of sheet products in the future, it is most desirable to find the type of heat treatment best suited to produce deep drawing properties with this material, as well as the limitations of various types of furnaces that might be applicable.

The writer and his associates have given much study to the problem, and have designed and built furnaces for continuous heat-treatment of a single strip, also for annealing in coils in batch-type furnaces, and for annealing in stacks in the sheet form. Experimental work has also been undertaken in an attempt to determine the physical properties obtainable by the various methods. While this study is still in progress and the results to date have not been wholly consistent, they may be of interest to those working in this field.

The continuous method of heat treatment in which, for example, the strip is passed through a furnace with protective atmosphere, in a single strand from the coil, is attractive, due to the short time in process. Compared to a box anneal, which, for wide sheets requires approximately one week for heating and cooling, only a few minutes would be required by the continuous process, and shipment could often be made the same day that the material is rolled. Furthermore, any desired time-temperature cycle could be employed, and it is not surprising that a great deal of interest has been evidenced in the possibilities of this type of furnace, for bright cold rolled material.

Before discussion of the test data, it might be well to review briefly the types of furnaces available, in order that the data and cycles referred to later may be more clearly understood.

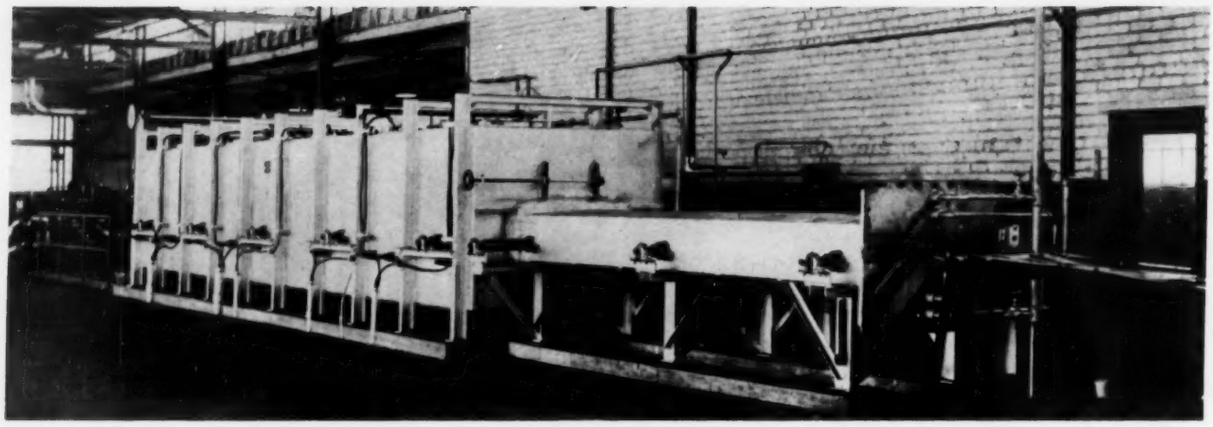
Figure 1 shows a continuous furnace for annealing wide strip, the strip passing through the heating chamber and cooling chamber, being supported on driven rolls, a protective atmosphere being provided to prevent oxidation.

Figure 2 shows an installation of cylindrical bell-type furnace for annealing in coils, and while this particular group of furnaces is used for annealing narrow strip, the coils being stacked approximately 4½ feet high, they are typical of furnaces for wide strip except that the size would be increased to take care of the particular size coils under consideration.

Figure 3 shows a base and retort for, and Figure 4 shows an installation of, a larger size furnace, to take two coils of wide strip, one coil stacked upon the other. It will be noted that this furnace employs a motor-driven fan in each of the bases, used to circulate the protective gas under the retort while cooling.

The fan tends to draw the heat out from the center of the stack of coils to the retort surfaces, maintaining a continuous circulation, which considerably reduces the time required for cooling from annealing temperature to such a temperature that the coils can be uncovered without danger of oxidation. A water spray on the retorts may also be used to further accelerate the cooling.

The essential difference between the furnaces illustrated by Figure 2 and Figure 4 is that, in Figure 2, cooling takes place at the natural rate, which requires



(Fig. 1)—**Typical continuous furnace for wide strip.**

more time, and consequently additional loading bases and retorts, as compared with the type of furnaces shown in Figure 4, in which cooling is accelerated by means of the fan.

The furnaces shown in Figure 2 require five bases and retorts to allow sufficient cooling time for brightness, while the furnaces shown in Figure 4 require only three bases, thus saving considerably in floor space required for a given tonnage, and somewhat in the cost of equipment.

Figure 5 shows an installation of rectangular bell-type furnaces for annealing sheets. This type of furnace can be built for any size sheet required, and for any height of stack, the only limits being the operating temperature, and the height of stack at which sticking of the sheets will not occur.

This type of furnace may be constructed with a recirculation cooling system for the protective gas, so that heat may be extracted while the load remains in the heating chamber, being cooled below oxidizing temperature before the heating chamber is removed. Or, hoods of sheet metal may be used to cover the stacks while heating and cooling, the heating chamber, at full temperature, being transferred from base to base at the end of the heating cycle, the stacks being allowed to cool naturally under the hoods.

Consideration has also been given to continuous furnaces to take light packs of sheets, for example one inch high, the packs passing through a heating chamber and a cooling chamber arranged in line, the packs being cooled below oxidizing temperature in a protective atmosphere. Figure 1 would also be illustrative of furnaces for this method.

With the continuous single-strip method, the time in process would be only a few minutes; for the pack method 5 to 6 hours; for coils in cylindrical bell-type furnace; 30 to 50 hours, depending on size of coils; and for stacks of sheets, 100 to 160 hours, depending on the size of stacks and width, or practically one week for heavy loads of wide sheets.

The characteristics of the continuous single-strip furnace, such as the short time in process, the uniformity of temperature cycle in all portions of the strip, also the feasibility of using higher temperatures as may be required, make this type of furnace very attractive.

There are certain inherent difficulties, however, such as possible marking of the strip by the supporting means, and the necessity of considerable auxiliary equipment, such as uncoiler, welder, pinch rolls, shear and reel, in line with each furnace, which makes the capital investment per unit a considerable item. For sheets these items would not be required, but the rolls would have to be spaced closer together.

A serious question is also presented as to whether consistent physical properties can be produced by this method.

For deep-drawing sheets, such as are used for automobile bodies, the best physical properties obtainable are generally desired, in order that the severe forming operations may be done without breakage of the sheets in the dies, or the roughening of the surfaces. While the requirements vary considerably, as do also the methods of producing satisfactory sheets, it may be said that, for this purpose, a soft sheet is usually required, about Rockwell B-42, as well as a sheet that will draw without causing a rough surface.

Quick shop tests for hardness are made on the Rockwell testing machines, and for ductility or drawing properties on the Olsen cup machine, the appearance of the surface of the drawn cup and the resulting necking or fracture, being important factors in the interpretation, as well as the depth reading of the cup. Tensile, elongation, and other tests are necessary for a full determination of properties, but these tests require time and labor.

In general, it may be said that a deep-drawing sheet of good quality will test about 42 Rockwell B and .420 Olsen Cup, and these values, together with a cup of smooth surface, well-necked, and a fine grained fracture, will probably perform satisfactorily in the die. At least a satisfactory sheet will have these properties, together with others which long experience in the technique of sheet manufacture have shown to be desirable for specific jobs.

Continuous furnaces for narrow strip have been employed for some years to a very limited extent, it having been found that the desired physical properties would result if the carbon is very low, for example, .04 or less. With a higher carbon content, it has been found difficult to get the material sufficiently soft for severe forming requirements.

It is difficult to make steel with a very low carbon content, at least by the methods generally employed, and it is well known that the carbon and other constituents segregate in the ingot while solidifying, tending to concentrate toward the center of the ingot and toward the upper end, (in rimmed steel practice) while the lower end of the ingot, and the whole surface for a considerable depth, may be low in carbon. When the ingot is rolled into slabs, which are later rolled on continuous mills into strip, the strip made from the lower portion of the ingot will have lower carbon content than that made from the upper portion and, furthermore, the structure of that from the upper portion will be laminated.

These facts are well known to steel makers, but to those who may not be familiar with them, the diagram and microphotographs of Figure 6 may be of interest. It should be understood that the diagram is merely illustrative, with values chosen at random.

The diagram indicates low carbon content of slabs from bottom of ingot, while slabs from the middle or upper portion will have low carbon content at the edges and surfaces, with higher content at the core portion.

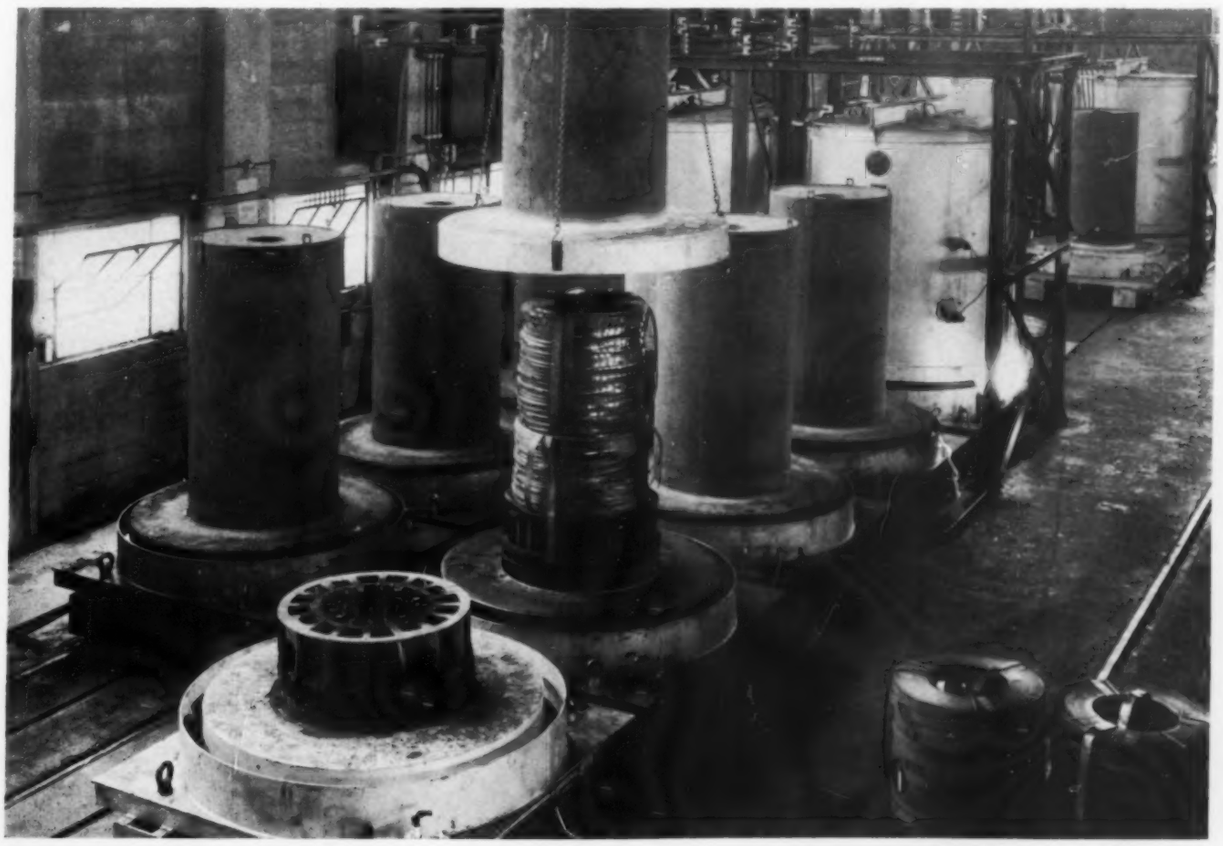
The difference in crystal structure at the edge as compared to the center is shown by the microphotographs, which were taken lengthwise and crosswise of a wide strip after cold reducing, the microphotographs embracing the full thickness of the strip.

It will be noted that the structure at the edge of the strip is quite uniform, but at the middle it is laminated, consisting of two surface layers and a mid-layer, of apparently different materials. When this strip is heat treated by normalizing, the edge of the strip shows a uniform, slightly large, grain structure, while the middle of the strip shows larger grains at the surfaces, with finer grains and darker appearance between the two surface layers, indicating higher carbon content in the mid-layer. The relative thickness of the mid-layer and surface layers will vary throughout the ingot.

The reason why steel with low carbon content will yield to quick heat treatment, while steel with a somewhat higher carbon content will not, is explained to the writer as follows:

We must distinguish between carbon in solution in the iron, and carbon out of solution. The limit of solubility of carbon at room temperature after very slow cooling, is .02 percent.

(Fig. 2)—Typical installation of cylindrical bell type furnaces for annealing strip in coils. Furnaces for wide strip would be similar but of somewhat larger size.



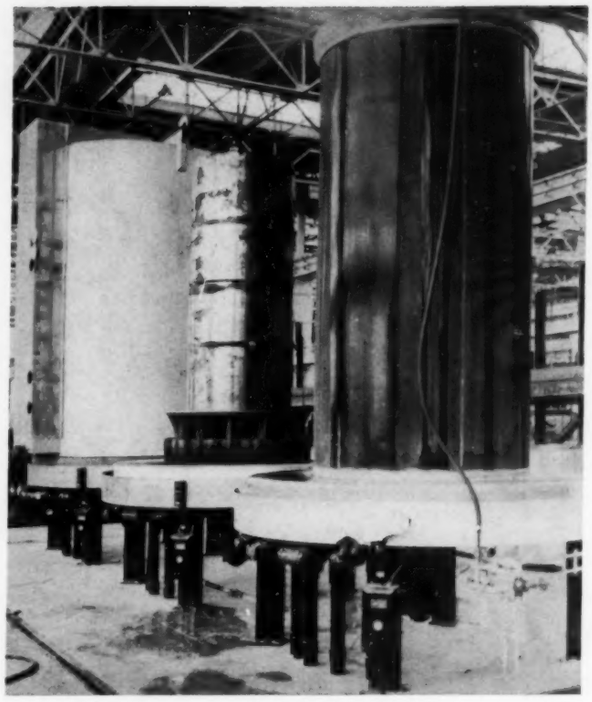
Above .02 percent carbon, the hard phase, Fi_3C, increases at the rate of 14 to 1, and this again is combined with 7 parts of iron to form pearlite, therefore the hardening constituent increases at approximately 100 times the rate of carbon increase.

The critical cooling rate decreases with increasing carbon, so that to obtain a given hardness, the higher carbon steel must be cooled more slowly, or conversely, for a given cooling rate, a higher hardness results.

For annealing just below the critical temperature, time is required for the carbon to agglomerate between the grains as carbide, leaving the ferrite with but the solubility limit of carbon, at the annealing temperature (the solubility limit at annealing temperature is about .06 percent), and then slow cooling is required, in order that the additional carbon which is in solution at annealing temperature, may be allowed to precipitate to its fullest extent.

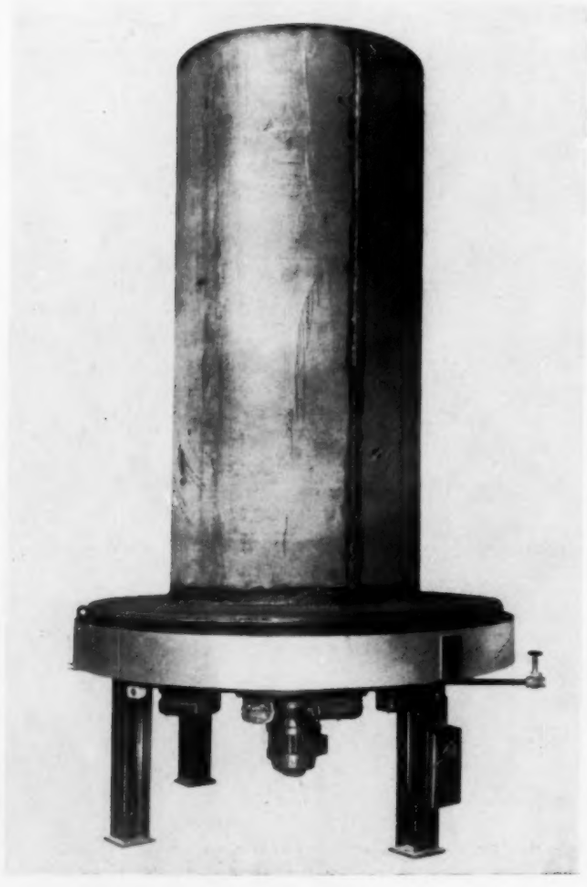
From the foregoing it is indicated, that for steel with higher carbon content, in order to get the material soft, it may be necessary to use a longer heating time and a slower cooling rate than is practicable with a continuous furnace, on account of the great length required for a unit of acceptable tonnage capacity.

The tests referred to herein were undertaken in an attempt to determine, if possible, limits within which



(Fig. 4)—Typical bell type furnace installation for annealing coils of wide strip.

(Fig. 3)—Base and retort for annealing 48″ wide strip.



the desired results could be obtained. The work has not been completed, and should therefore be considered as of a preliminary nature.

The continuous tests were conducted in a roller hearth furnace, shown in Figure 7, equipped with adjustable cooling apparatus in the several sections of the cooling chamber, so that varied rates of cooling can be obtained.

The tests consisted of a great number of individual runs, passing single sheets, 20 gauge, 18″ wide and 48″ long, through the furnace, at various travel speeds, with various furnace temperatures and cooling rates. Test thermocouples were welded to some of the sheets. Typical examples of the heating and cooling curves were selected, and are shown in Figure 8.

Also some of the sheets were treated at 1850°F. and subsequently reheated, as shown in Figure 9.

Other tests were conducted on three different lots of steel simultaneously, carrying the temperature to 2100°F. Also data was recorded from bell-type furnaces, annealing large coils of wide strip.

Summarized results as to Olsen Cup and Rockwell B hardness for the first series are given in Table I, designated as continuous and batch methods.

In none of the tests of this series in the continuous furnace, was it possible to get the hardness lower than 48B, and this was approached in only a very few instances, most of the readings being 54 to 60, as indicated by the average values in the tabulated data on the curve sheet.

Reheating to a lower temperature after normalizing at 1850°F. (the sheets were cooled between treatments as the curves show), appears also to have no appre-

ciable effect on the hardness or cup values, within the range of the tests, and in fact, in none of the tests of this series was it possible to produce a softness which would meet the requirements previously given for deep-drawing sheets, i.e., values of 42B hardness and .420 Olsen Cup.

TABLE I

20-Gauge Cold Reduced Strip

Summary of Olsen and Rockwell Readings

by

Various Methods of Heat Treatment

Continuous Method LOT A: in furnace Fig. 6	Olsen Cup	Rockwell B Hardness
Fig. 8 Normalize—1500 to 1735°F.....	.364–.392	48–60
Fig. 9 Normalize—1850°F.....	.374–.411	52–60
Fig. 9 Normalize—1850 and reheat (1220 to 1530).....	.372–.407	50–62
LOT B: in furnace Fig. 1		
Normalize—1700°F., 4 minutes.....	.415–.466	53–58
Normalize—1700°F., box anneal 1300...	.440	40
Batch Method LOT A: Same Steel with Time Anneal in Batch Furnace		
10 min—1500 deg. F.....	.411–.449	50–58
20 min.—1500 deg. F.....	.415–.426	49–52
1½ hr.—1500 deg. F.....	.442–.449	46–49

NOTE: The Olsen cups were fractured in this series, and the readings are, therefore, higher than in other tests referred to later, in which the cups were necked but not fractured.

Material of Lot B, heat-treated in furnace Fig. 1, gave good cup values when normalized, but it was hard, as indicated by B 53 to 58 value. This same material, box annealed at 1300° after normalizing, gives Olsen Cup of .440 and hardness of 40, which would be considered an excellent steel. This of course should be expected.

The same material as Lot A, annealed in batch type furnace at 1500°, even with 10 minutes time, gives a good cup value. (.411 to .449), but the material is hard, (B50 to 58). Twenty minutes time gives considerably better softness, and 1½ hours' time a still better softness, although not yet sufficiently soft to meet the stated requirements.

Coils of wide strip, annealed in bell-type furnaces, at 1350°F. and 1400°F., gave respectively, B43 and B38 average values.

Packs of 20-gauge sheets, 1″ high, (from Lot A) were annealed in the furnace shown in Fig. 7 at 1500°F. with 1½ hours and 2 hours total time in the heating chamber. Approximately 1 hour is required to reach 1400°F., so that the tests gave respectively 30 minutes and 60 minutes above 1400°. The 2-hour cycle gives a very uniform hardness value of 55-B. Three hours total time in the heating chamber at 1350°F. gives uniform hardness values 50-52B. The cooling rate, however, was quite high.

While not offered as a reason at this time, as to why softness did not result, a comparison of cooling rates by various annealing methods will be of interest.

In this connection, Figure 10 shows the heating and cooling rates obtainable with the usual high stacks of sheets in a rectangular bell-type electric furnace with recirculation cooling system, and the slope of the datum lines indicate the approximate cooling rates obtainable. It will be noted that 30″ wide sheets can be cooled at about 100° per hour; 48″ wide sheets about 50° per hour, and 84″ wide sheets, about 25° per hour, these being temperatures at the center of the stack. Some of these curves are from test data and others are projected from the test data, but they indicate, in general, minimum cycles obtainable with the width of sheets stated.

In current practice, using heavy cast steel boxes to cover the sheets, it is well known that approximately 100 hours is required for cooling to uncovering temperature, or even more for very wide sheets, indicating an average rate of approximately 10°F. per hour, or a maximum rate of probably 20°F. per hour.

It is surprising to compare these rates with the cooling rates which occur in a continuous furnace, and indicated approximately by the datum lines on Figures 8 and 9. For convenience, this comparison is tabulated in Table II. A study of this Table will show the tremendous rate at which material cools in a continuous furnace as compared to the batch method.

TABLE II

Comparison of Cooling Rates of Strip and Sheets

by

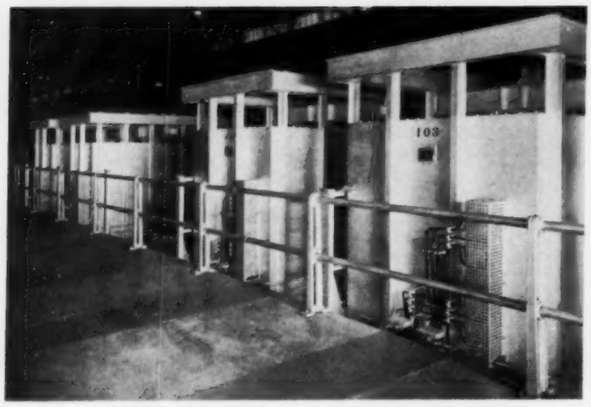
Various Methods of Annealing

Type of Furnace	Kind of Material and Loading	Method of Cooling	Cooling Deg. per Minute	Rate Deg. per Hour
Continuous	Single strip—20 ga.	Fast—Fig. 8	800	48,000
Continuous	Single strip—20 ga.	Medium—Fig. 8	300	18,000
Continuous	Single strip—20 ga.	Slow—Fig. 8	200	12,000
Continuous	1″ pack, 20 ga. sheets	Fast	50	3,000
Bell-type, cylindrical	Coiled strip (Small loads)	Natural—Fig. 11		100
Bell-type, cylindrical	Coiled strip (Large loads)	Forced Natural		70
Present Practice,	Stacks of sheets.	Narrow		50
Box-type furnaces	Cast steel covers	Natural Wide		20

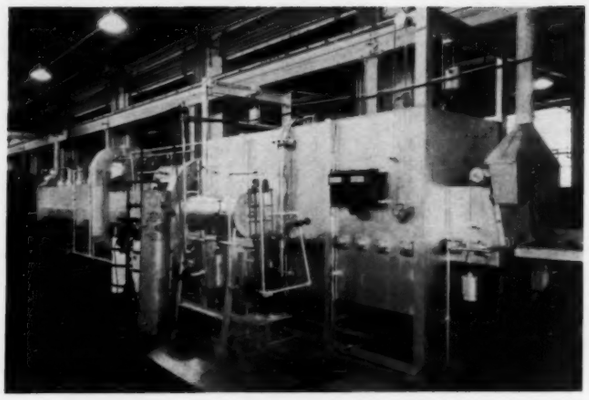
The results from the foregoing tests in the continuous furnace were not consistent, since successive sheets normalized on the same cycle gave widely varying values. Variations in the steel itself were, therefore, suspected. It was also suggested that higher temperatures might be beneficial.

Two additional lots of sheets (designated later as Lot 1 and Lot 3) were secured from different sources, and samples from these and from the original lot were run through the furnace, immediately following each other. Temperatures from 1400 deg. F. to 2100 deg. F. were used.

Temperature conditions in the furnace and cooling chamber were carefully stabilized by passing dummy sheets through continuously, and allowing sufficient



(Fig. 5)—Installation of rectangular bell type furnaces for annealing sheets.



(Fig. 7)—Roller hearth furnace used for normalizing and annealing experiments, arranged for controlling the cooling rate of sheets or strip.

time after each temperature adjustment for thorough equalization.

A typical temperature curve is shown by Fig. 12, and the hardness results by Fig. 13. It should be noted that these sheets were run under identical heating and cooling conditions, the only variable factor being the material itself.

The hardness of Lot 1 drops to B50 at 1700 deg. F. and higher temperatures have no appreciable effect. The results from Lot 2 are inconsistent, and Lot 3 does not yield at all.

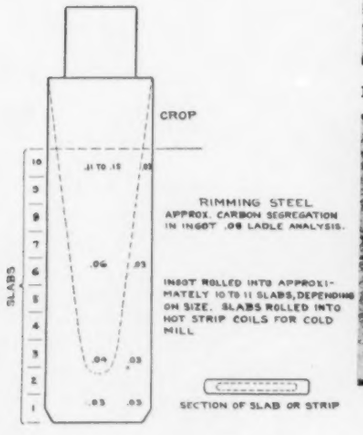
For check purposes, additional sheets from Lot 1 were run at 1800 and 1850 deg. F. at the same speed and at higher and lower speeds, with results as given on the curve sheet.

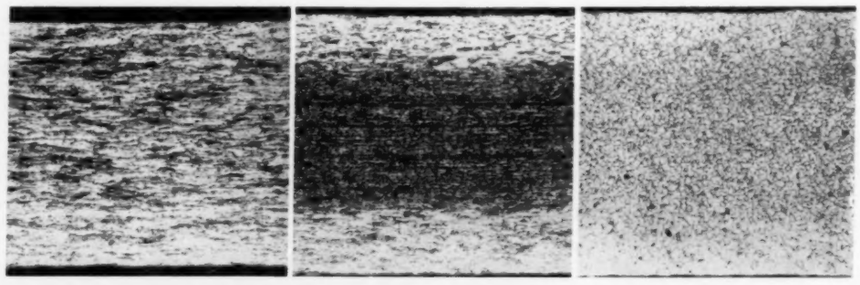
Packs of three sheets from Lot 1 were also run at 1900 deg. F. at three different speeds as noted. This gave a lower range of hardness, but there was no relation to time, the variations being practically the same for all three speeds.

The results from these packs appear quite remarkable, as it would hardly be expected that a three-sheet pack, with only three minutes in the furnace would result in the softness obtained. These are the softest sheets secured in any of the tests in the continuous furnace. The explanation might be looked for in the slower cooling rate obtaining in a three-sheet pack, although there was no difference in hardness between the top, bottom or middle sheets.

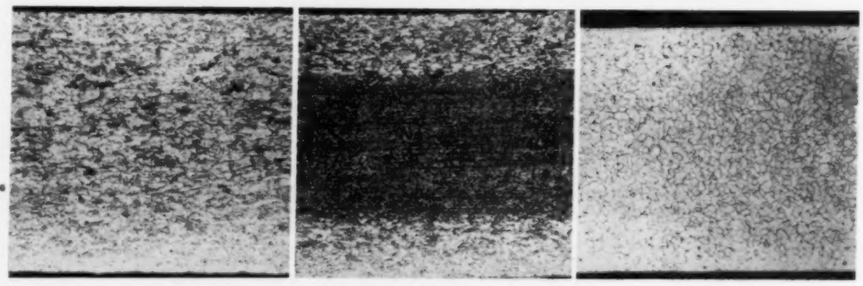
The conclusion appears justified, at least tentatively, that material of the nature of Lot 1 will yield to any temperature or time treatment, provided only that it reaches a given minimum temperature, and that additional softness is secured by slow cooling. Also that single sheets of Lots 2 and 3 will not yield at temperatures and times practicable in a continuous furnace. Unfortunately the test furnace was not equipped for very slow cooling so that this phase could be further explored.

(Fig. 6)—Diagram to illustrate carbon segregation in ingot, and slabs and strips made there from. Also microstructure of edge and middle of strip before and after heat treatment.

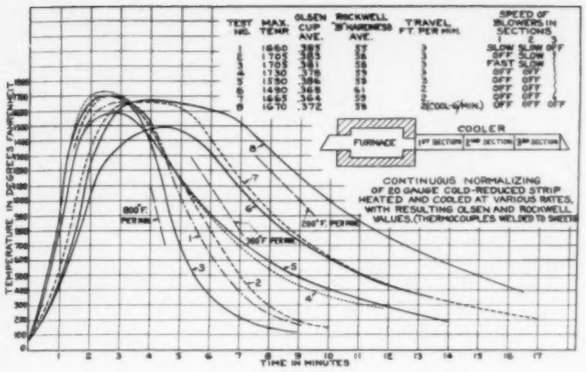




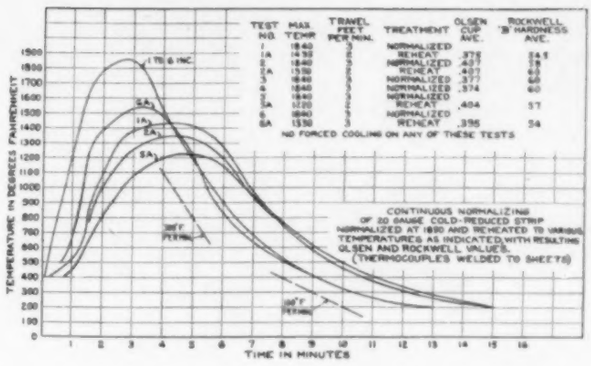
Edge of Strip—Longitudinal Sec. | Middle of Strip—Longitud. Sec. | Middle of Strip



Edge of Strip—Cross Section BEFORE NORMALIZING | Middle of Strip—Cross Section BEFORE NORMALIZING | Edge of Strip NORMALIZED



(Fig. 8—Typical heating and cooling cycles of 20 gauge strip in furnace. (Note Fig. 7)



(Fig. 9—Typical normalizing and reheating cycles of 20 gauge strip in furnace. (Note Fig. 7)

The Olsen Cup readings of Lot 1 material above 1700 ranges .405 to .417. The cups were necked but not fractured in the testing machine. Again there appears to be no relation between cup value and treatment, all being within a narrow range.

While Lot 1 gave the best results of any of the materials secured for these experiments, there is no reason to believe that still better results could not be obtained by testing additional lots. It is apparent, however, that the variations in the materials are such that the furnace alone cannot be expected to control the resulting physical properties, unless designed with a full knowledge of the nature of the material to be treated. It is also apparent that much study will be required in order to design equipment that will give the desired results with such widely varying materials as Lots 1, 2 and 3.

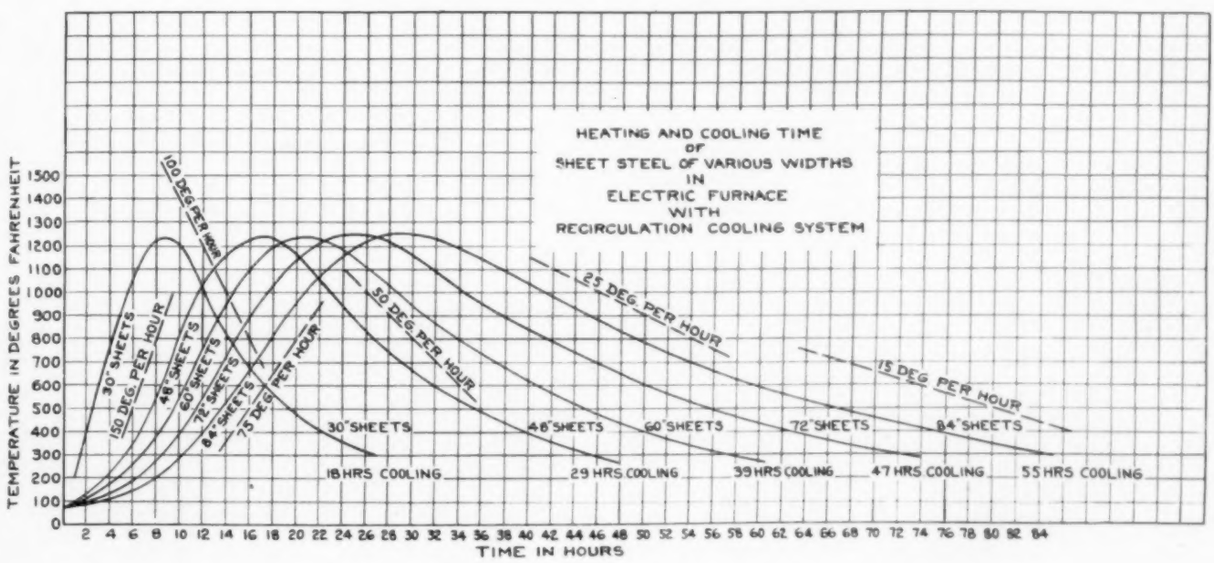
Another interesting observation in connection with these tests is that no visible grain enlargement was found on the drawn cups from any of the tests on any of the lots of material. Stretcher strains, however, were sometimes in evidence. All samples were tested soon after heat treatment, and without cold rolling.

Grain growth was deliberately attempted by running sheets at 1900, 1950, 2000 and 2050 deg. F. for eight minutes time, without visible effect.

It would be interesting and instructive to conduct tests on materials from known parts of the ingot, and with known history. It is believed that data could be secured that would be consistent, if work is done with known materials.

Regarding the batch method for annealing in coils, it may be said that a considerable number of electric furnaces of this type are now in regular use, and their characteristics as regards heating time, output, and temperature distribution have been well established. The uniformity of final temperature distribution is indeed remarkable, a distribution curve from a furnace of the type of Fig. 2 being shown in Figure 11. The uniformity, however, is best shown by the tabulated

(Fig. 10)—Heating and cooling rates of stacks of sheets of various widths in electric furnace with recirculation cooling system.



data which, for the last hour of the run after temperatures were equalized, is given in Table III. It will be noted that the total variation throughout the load is 7°F. Other loads gave 5°F. variation, and others absolutely no deflection on a portable instrument when switched from one thermocouple to another.

With the uniformity of temperature distribution thus obtainable, it is possible to control the annealing cycle accurately, and furthermore, it is possible to hold at temperature for 1 hour, 2 hours, 3 hours, or as long a time as desired, when the required cycle to give the physical properties has once been established. These furnaces are equally suited to high carbon or low carbon steel.

TABLE III

Final Temperature Distribution in Load of Coiled Strip in Cylindrical Bell-type Furnace

Time	Control Inst.	Bottom		Middle			Top	
		Inside	Outside	Inside	Center	Outside	Inside	Outside
6:30 PM	1220	1200	1200	1200	1200	1200	1205	1200
7:30 PM	1220	1200	1198	1200	1200	1205	1205	1205

Table IV gives Olsen and Rockwell readings from a load of coils of wide strip, annealed in a bell type furnace. The readings were taken across the strip, from one edge to the other.

TABLE IV

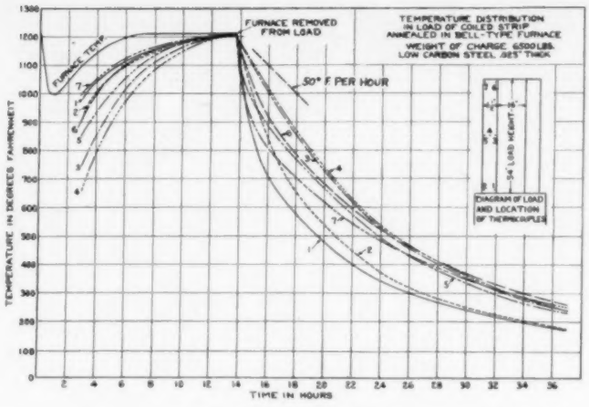
Typical Olsen and Rockwell Tests

Wide Strip in Coils

Annealed in Bell Type Furnace

	Gauge	Olsen Cup	Rockwell "B" Hardness
Bottom Coil			
	.040	.425	33 35
	.041	.415	36 38
Outside Turn.....	.041	.420	37 38
	.041	.420	37 38
	.040	.410	37 39
	.042	.420	31 33
	.042	.420	35 36
Inside Turn.....	.043	.430	35 37
	.043	.430	34 35
	.043	.435	32 34
Top Coil			
	.042	.430	37 38
	.043	.420	38 40
Outside Turn.....	.043	.410	37 39
	.043	.415	37 38
	.042	.425	35 37
	.041	.415	35 36
	.041	.410	37 39
Inside Turn.....	.042	.410	37 39
	.042	.410	35 36
	.041	.415	34 36

The objection has been raised by some operating men that annealed coils are difficult to handle, due to their softness and likelihood to get out of shape. For these reasons, it is often preferred to anneal in the sheet form, i.e., shear before annealing rather than afterward. However, a decided advantage of the bell-type furnace for annealing in coils is the fact that higher temperatures can be used, as compared to stacks of sheets, without danger of sticking. With cold reduced material it is generally considered that higher annealing temperatures are beneficial.


FURNACE REMOVED FROM LOAD
TEMPERATURE DISTRIBUTION IN LOAD OF COILED STRIP ANNEALED IN BELL-TYPE FURNACE
WEIGHT OF CHARGE 65001 LBS.
LOW CARBON STEEL .025" THICK
50° F PER HOUR
DIAGRAM OF LOAD AND LOCATION OF THERMOCOUPLES
TEMPERATURE IN DEGREES FAHRENHEIT
TIME IN HOURS

(Fig. 11)—Temperature distribution in load of coiled strip in cylindrical bell-type furnace and cooling curve (natural rate).

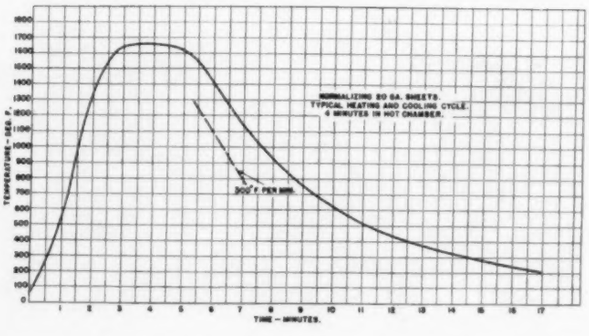
Another advantage is the large tonnage capacity per unit of floor space, due to vertical loading, and short annealing cycle.

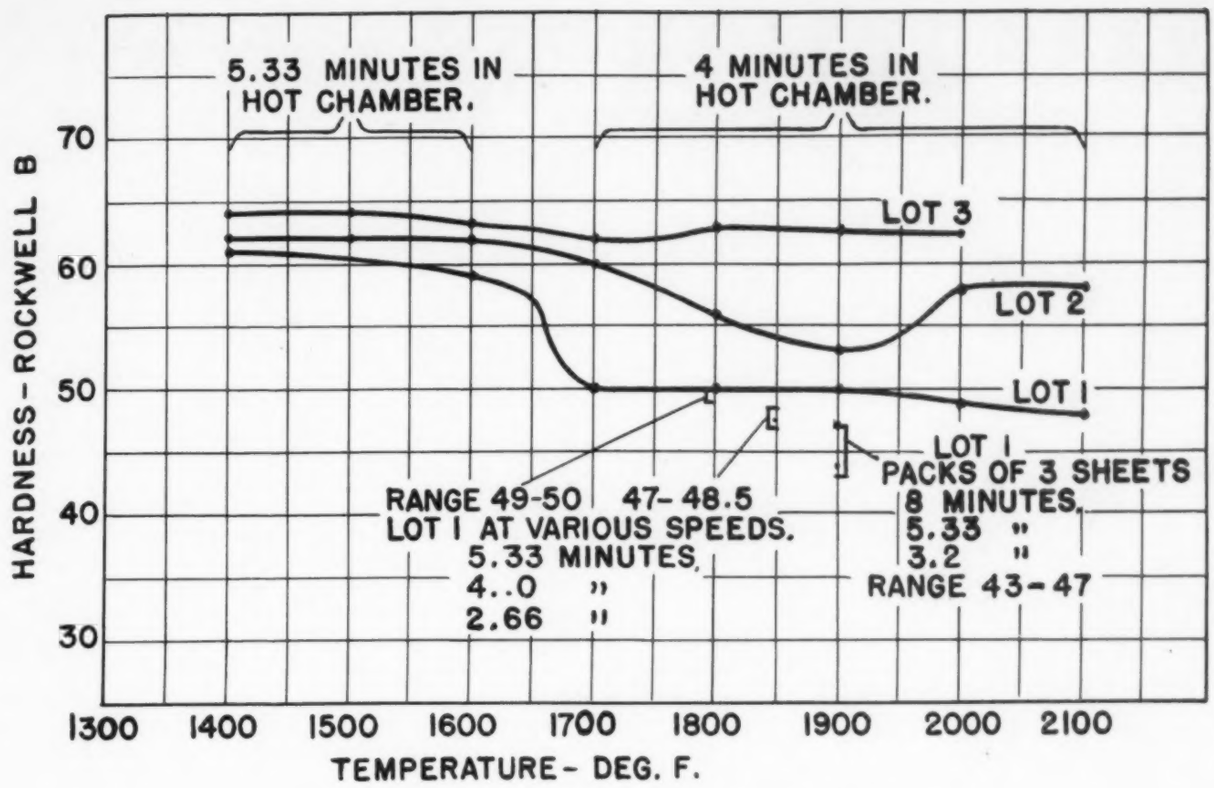
The large furnace shown in Figure 4 was designed for operation at 1400 deg. F. It will anneal two coils of 48" wide strip, each coil weighing 16,000 lbs., total load 32,000 lbs., in about 20 hours heating time and 27 hours cooling time. The equipment consists of one heating chamber, three bases with motor-driven fans, and three retorts.

The energy requirements will depend on the size of furnace and load and on the annealing temperature. The large furnaces, Fig. 4, at 1400 deg. F. require 165 KWH per ton (2000 lbs.,) and the smaller furnaces, Fig. 2, at 1200 deg. F. will require 132 KWH.

There is no limit to the width of strip that could be annealed in these bell-type furnaces. They are provided with a central heater extending downward into

(Fig. 12)—Typical temperature curve for tests. (Note Fig. 13)


NORMALIZING 20 GA. SHEETS
TYPICAL HEATING AND COOLING CYCLE
6 MINUTES IN HOT CHAMBER.
300° F. PER MIN.
TEMPERATURE - DEG. F.
TIME - MINUTES.



(Fig. 13)—Variation in Rockwell hardness of three lots of 20 gauge cold reduced steel, normalized under identical conditions.

the stack of coils, so that heat is applied from the inside as well as the outside, and the rating of the units is proportioned to the total heat required by the inside and outside portions of the coils, so that maximum speed of heating is secured, together with the ultimate in uniformity of temperature distribution. If provided with fans, the material may be cooled at a considerably higher rate as compared to natural cooling, which shortens the time in process.

The rectangular bell-type furnaces for sheets, illustrated by Figure 5, also provide uniformity of temperature distribution, in that the base is provided with heating unit, uniformly distributed over its area, so that the bottom of the load is brought up at the same rate as the top, and after allowing the necessary period for temperature equalization, cooling may be started with a short holding period at temperature, or a long holding period as may be required.

The equipment consists of one heating chamber, 4 bases and 4 retorts, the sheets being heated and and cooled under the retorts. The heating chamber is transferred from base to base at full temperature at the end of each heating cycle.

The approximate heating time and energy required for wide sheets is given in Table V, based on stacks 48 inches high, and all sizes annealed in furnace for 84″ x 144″ sheets.

TABLE V

Size Sheets	Approx. Wt. of Load Tons	Heating Time Hours	KWH per Ton at 1150°F	KWH per Ton at 1250°F.
60″x120″	40	35	140	155
72″x120″	50	40	135	150
72″x144″	60	40	130	145
84″x144″	70	48	125	140

With these types of electric furnaces, in which the bottoms and the tops may be brought up together, at the same rate and to the same final temperature, and equalized for any length of time that the requirements may dictate, it is obvious that complete control of the annealing cycle is established and cycles may be duplicated at will.

Finally, it should be repeated that the tests in the continuous furnace reported herein, are regarded as of a preliminary nature, having been made with comparatively few lots, obtained at random and with unknown history, but presumably representative of commercial materials.

It is not intended that they should be considered as a basis from which conclusions as to the practicability of continuous furnaces could be drawn, but it is hoped that the data will be of interest to those who have been studying this problem, and possibly of some value as points of departure for further study.

DISCUSSION

PRESENTED BY

M. J. CONWAY, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.

H. V. FLAGG, Combustion Engineer, American Rolling Mill Co., Middletown, Ohio

A. N. OTIS, Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.

A Member: Were these tests made entirely on material produced by the cold reducing methods?

A. N. Otis: Yes, it was all cold reduced material. We used 20 gauge material in all of the tests, so that the results would be directly comparable.

A Member: Did you ever try any of the old-fashioned grade of hot-rolled material which had been cold-rolled?

A. N. Otis: No, we did not. Our chief interest at present, is in cold reduced material, because the bulk of sheet products in the future will probably be made from that material.

M. J. Conway: Mr. Flagg, have you anything you wish to add or a question to ask?

H. V. Flagg: I would like to ask one question. Were the samples made on the continuous furnace taken from the same coils as those made in the coil furnace?

By inference you draw the conclusion that consistent results cannot be obtained in a continuous furnace. Then you show that by slow heating and slow cooling in the coil furnace, excellent results are consistently obtained.

I wanted to bring out the point, that the comparison between continuous furnace and batch furnace normalizing should have been based on runs on particular batches of steel divided between the two methods of processing in order to get a true comparison. If that was not done, it seems to me that comparisons fail.

A. N. Otis: A comparative test such as you suggest would be desirable, and should be made when opportunity offers. We have no facilities for handling these coils, that is, for uncoiling and shearing, as the material is stiff and springy as you know. To get a true comparison, it would be preferable to take a sample from each end of the coil and from the middle.

We have run quite a number of coils ourselves and have records from plenty of others annealed in these bell furnaces. We have not there encountered the variations referred to.

In our tests, we sometimes wanted to check results from a given sheet, and would run through another one from the same stack under identical conditions, but the results would not check, indicating non-uniformity among the sheets of the stack. I should add, however, that the results from lot No. 1, referred to on the curve sheet illustrated in the paper, did yield very consistent results.

If we are given the problem of designing a continuous furnace, we can heat the material and we can cool it on any cycle that you may specify, or on any cycle which may be found from tests to be desirable, but we would be unable to make a statement as to resulting physical properties, except on the basis of sample sheets which would be submitted.

I do not wish to be understood as adopting a negative attitude toward the possibilities of continuous furnaces, or of concluding that good results cannot be obtained from them. On the contrary, this is a very important development from the standpoint of the electric furnace engineer. Furthermore, sufficient data has not yet been presented to form the basis of such a conclusion.

The purpose of the paper is to point out inconsistencies which have been encountered at the very beginning of a study of this problem, and the necessity of considering them in the design of continuous furnaces. Possibly some of you have encountered the same difficulties, but I know of no published articles that throw light on the subject.

M. J. Conway: It appears to me that a paper on segregation and its effect on subsequent treatment is a subject worthy of another paper. Mr. Otis has certainly pointed to the importance of the subject in his paper.

A. N. Otis: It appears, Mr. Chairman, that the steel companies, if they have equipment of an adjustable character with which to study the effect of these temperature cycles, are in a better position than we are to do the experimental work, as they can follow the material all the way through, even to the forming dies.

M. J. Conway: I can assure you, from my observation, the Steel industry is certainly busy from a research work standpoint, not only on strip steel, but steel for every purpose and the results of this research work are gratifying as may be proven from the steady improvement of steel quality and its adaptibility to strains and stresses that were thought to be impossible a few years ago.

Is there anyone else who would like to discuss this problem?

It seems you have no further contenders, Mr. Otis. Probably someone in the audience whom you know can add something to your paper. Have you anyone you wish to suggest?

A. N. Otis: No, I haven't, but I do hope that these results, which are contained in this current issue of the "IRON AND STEEL ENGINEER" will be worthy of some interest and stimulate further study. There is probably some continuous method, possibly in conjunction with metallurgical control, by which this material can be annealed, even though it does vary considerably. Light packs of sheets might offer a possibility, combined with slow cooling, and there is little doubt that a suitable method will ultimately be found.

OPEN HEARTH FURNACES

FACTORS TO BE CONSIDERED IN INSULATION

BY GILBERT SOLER, Director of Research
Timken Steel and Tube Co.
CANTON, OHIO

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania, September 24, 25, 26, 1935

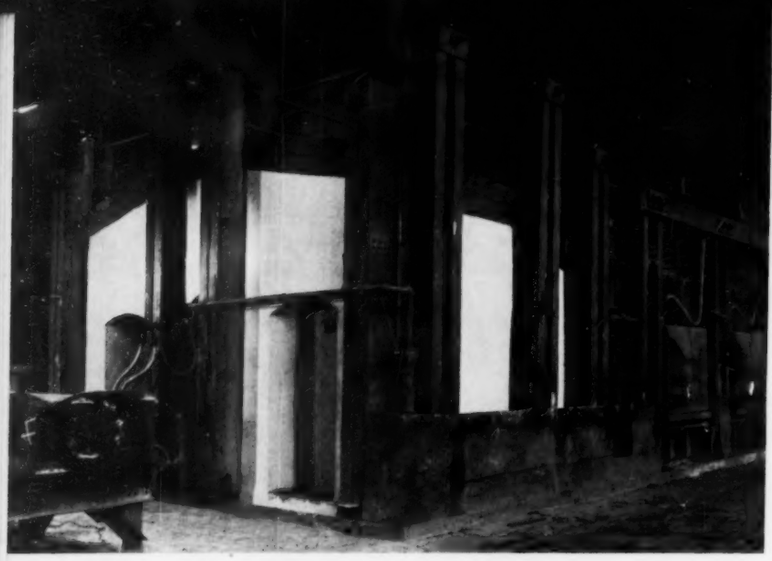
▲ **THE MERE APPLICATION** of an insulating material to certain parts of an open hearth furnace does not begin to take care of insulation, for many other factors are involved. The design of the furnace and how it is operated must be given careful consideration before making a decision as to whether certain parts should be insulated, and if so, with what type of material. Likewise, the type of fuel used and how flame and draft control is handled plays an important part in the successful solution of the problem. And finally, the human element enters into the problem of insulation to a rather marked degree.

Many advantages can be secured from properly designed and engineered insulation projects in which all factors are taken into consideration. Fuel savings alone may amount to as much as 15%, and furnace time per heat may be decreased as much as 4% because of faster melting and less chilling of the furnace between tapping and charging. It is difficult to say definitely just how much longer refractories will last in an insulated furnace, but the more uniform temperature maintained throughout the brick, particularly in the case of silica brick, reduces spalling to a marked degree. Decreased slag pocket deposits, better combustion control, cleaner tapping, plus greater tonnage, reduced refractory costs per ton, and the substantial saving in fuel costs, may all be listed as advantages which insulation should aid the operating man to secure. Also, in some cases the scrap iron content of a charge may be increased, with a resultant saving in the cost of raw material when the furnace has been properly insulated, thus making possible another saving due to the favorable differential in the cost of scrap over pig iron. Further, during short periods when the furnace is shut down, insulation will materially reduce the amount of fuel necessary to keep the furnace hot.

GILBERT SOLER

Insulating material must be selected and supplied according to both the properties of the material and the conditions under which it will be used. In the case of regenerators, flues, and fantail arches approximately 4½ inches of insulation usually will give the best results. Insulating brick is ordinarily used on new construction, but plastic or granular material can be supplied satisfactorily when insulating existing furnaces. Material for use in the locations mentioned should not disintegrate, fuse, or flux with firebrick at temperatures up to 1500° F. Likewise a material of low heat conductivity should be selected and shrinkage kept to a minimum to avoid cracking or opening of joints which might permit the infiltration of cold air into the furnace.

As approximately 30% of the total heat conduction losses on uninsulated open hearth furnaces occur in the slag pockets, uptakes and downtakes, these points offer a good opportunity for treatment. Existing construction is ordinarily most easily insulated with a plastic material, building it up in layers and finishing the surface with portland cement or a similar binding material. From 3 to 5 inches of insulating material may be used successfully. On new construction where insulation is provided for in the design, brick or block are ordinarily installed. When selecting the material for use in these locations, it should be remembered that temperatures as high as 2000° F. may be reached on the surfaces to which the insulation is to be applied. Low heat conductivity and minimum shrinkage are



Insulated Open Hearth Furnace showing endwall and portion of frontwall.

essential, and of course the material chosen should not disintegrate, fuse, or flux with the brick to which it is applied.

Effective insulation of open hearth furnaces above the floor level calls for special study and particular care in the application of the material selected. Low heat conductivity may be sacrificed to some extent in favor of a higher degree of refractoriness, and the thickness of the insulating layer modified according to temperatures and operating conditions. For example, a short furnace which is filled with flame cannot carry as heavy an insulating layer as a longer furnace. In any case, the amount of insulation should be based upon conditions as they will exist after the furnace walls have thinned down in service rather than on the wall thickness and brick insulation interface temperature of a new furnace.

Proper insulation of open hearth furnace roofs will effect the largest proportion of fuel saving and increase refractory life, provided that proper flame and combustion conditions are maintained. These factors are particularly important and must be carefully studied in conjunction with the question of insulation. A low roof in a furnace filled with flame will not permit the use of as heavy a layer of insulation as will a higher roof, and in some cases it has been found economical to elevate the roof when applying insulation. Ordinarily from 2½ to 3 inches of insulation is all that can be used successfully.

Roof movement during heating up or cooling down periods complicates the application of insulating materials. For this reason plastic or granular material is usually considered more satisfactory than brick or block. The plastic material is more easily applied, shows less cracking and buckling, and gives a higher recovery value, avoiding the heat losses through the many joints which exist when insulating brick or block are used on furnace roofs.

The front wall of a furnace is perhaps the most easily handled so far as insulation is concerned. Air infiltration around the doors, plus the fact that most doors are water cooled, keeps front walls cooler than the other faces and thus simplifies insulation problems. Backwalls offer more difficulties, but nevertheless have been successfully treated. Insulation not only reduces heat losses but also helps to eliminate air infiltration, which in some instances is considerable. The type of bottom used in the furnace will have some effect on heat conduction losses, for dolomite has a lower rate of heat conductivity than magnesite. Also, it has been noted that furnaces on which the backwalls are insulated show cleaner banks, work more evenly, and tap cleaner than uninsulated units, with no decrease in refractory life.

When furnace design and combustion conditions are studied in advance, endwall insulation will offer no serious problems. The type of refractory used in the endwall bulkheads may effect the treatment given when insulating. High velocities of outgoing combustion products will result in violent flame impingement and also a greater heat transfer to the brickwork, as the rate of heat transfer is increased with increasing velocity.

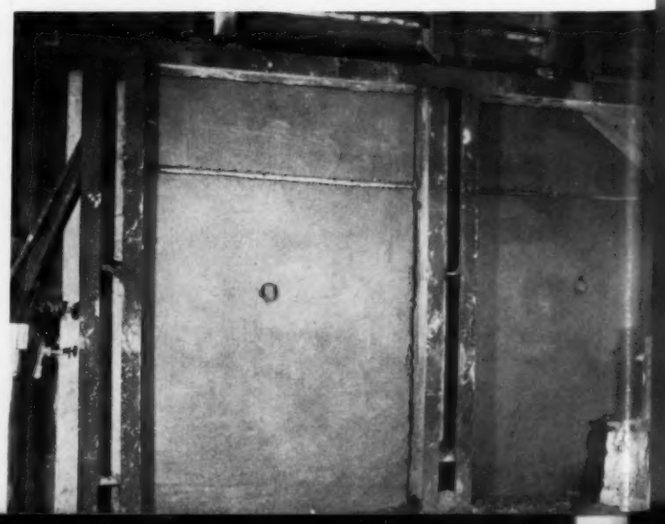
Unless fuel and air input are adjusted to compensate for the effect of insulation on temperature, drafts, and velocity, maximum economy will not be secured. In fact, fuel efficiency may be decreased and at the same time refractory life reduced by the higher temperatures which may prevail. Consequently, it should be remembered at all times that furnace insulation is not a single factor, but must be used in conjunction with other modifications in furnace design and operation if the maximum benefit possible is to be obtained.

Thus, when conduction heat losses are reduced by insulation, more heat is available to the charge unless fuel input is changed. The operator then has a choice between increasing the rate of production of his furnace and keeping fuel input the same or holding the production rate constant and cutting down on the amount of fuel used. One method offers an economy in time and the other in fuel, so the choice will depend upon which factor is the more important at the time, being limited of course by furnace and operating conditions.

The effect of insulation on reducing air infiltration should not be overlooked. Air which formerly leaked into the furnace is taken through the checkers after insulating a furnace, resulting in a higher air temperature and an increase in flame temperature unless proper adjustments are made. This possibility coupled with the decrease in conduction losses makes it imperative that an insulated furnace be closely watched at first to see that safe working temperatures are not exceeded.

When the same heat input is maintained in a furnace after insulation by reducing the fuel and air input, the velocity of the outgoing gases will be decreased. This in turn lowers the rate of heat transfer to the brick and reduces the wear on the refractories in the endwalls

Insulated checker chamber bulkhead.



and downtakes. Likewise, the lower velocity of the gases reduces the amount of dust carried into the slag pockets and checkers. Further, as the volume of combustion products is decreased due to less fuel being burned, a lower pressure will exist in the furnace. This should be corrected by lowering the furnace damper enough to produce the desired hearth pressure.

Frequently it is safe to operate a furnace at higher temperatures than were possible to attain economically before insulation. In such instances, the fuel input may be allowed to remain unchanged. As the air will go through the checkers, flame temperature will increase and greater heat input will result. At the same time, the increase in hearth pressure will increase the velocity of the outgoing gases, and unless proper provision has been made in the furnace design, more dust will be found in the slag pockets and checkers, and evidences of increased wear will soon appear on the endwalls and downtakes. Reducing the hearth pressure by opening the stack damper will still further increase the outgoing gas velocity, making it imperative to study the furnace design carefully before attempting to increase the furnace production rate by increasing the heat input.

Insulation may have a very pronounced effect upon refractories entirely aside from wear due to increased gas velocity. Even though the inner face temperature remains the same, the outer face of the refractory lining will be increased in proportion to the amount and efficiency of the insulation applied. Consequently, the penetration of the high inner face temperature into the refractory will be greater than in the case of an uninsulated furnace. When too much insulation has been used where high temperatures are encountered, the outer face of the refractory lining may reach a temperature at which the effective safe load strength of the brick will be exceeded. Temperatures as low as 2300° F. may be sufficient to weaken magnesite, chrome, or fireclay brick. The fact that silica brick maintain a safe strength to within 100° F. of their fusion point makes them particularly suitable for use in furnaces which are insulated.

Thermal spalling is reduced by furnace insulation, providing that the refractories have been properly matured in service. This is due to the decrease in the temperature differential between the inner and outer faces, thereby reducing differential thermal stresses. However, in the case of silica brick, proper maturing is essential because of the allotropic changes which may occur during heating and cooling. The major inversions, together with the approximate changes in linear expansions are:

to quartz —1069° F. (0.5% expansion)
to crystobalite—389° to 527° F. (1.0% expansion)
to tridymite —242° to 325° F. (0.25% expansion)

As quartz represents about 30% of a silica brick crystobalite and tridymite making up the balance, any of these inversions may occur. However, if the outside temperature of the brick is maintained above 1200° F., these inversions will not occur and consequently internal fracturing of the brick due to allotropic changes will be avoided. Insulation aids materially in maturing silica brick, the change of the quartz content into crystobalite and tridymite occurring to a greater depth in the brick and thus giving a more stable structure.

Insulated slag pocket bulkhead.

However, the full economy made possible by insulation can only be secured when cooperation on the part of the furnace operators has been achieved. It is comparatively easy to convince a technician that insulation is a good idea, but selling this idea to the men who must change their habits is a far more difficult task and one that requires a considerable degree of diplomacy if best results are to be attained. Changes in operation due to insulation and the reasons for these changes must be explained to furnace operators in their own mill language, avoiding the use of technical terms. However, the men can readily appreciate how covering cracks will cut down leakage (instead of reducing air infiltration), how a furnace will get hot quicker when the heat cannot get through the walls as easily as it did before, and that if more fuel is burned that more air must be used, with the result that a greater amount of burned gases must get out of the furnace. A non-technical explanation of how this affects refractory life and steel making will arouse their interest and a sincere cooperation will result, but the use of too many technical terms will cause the men to consider that the whole thing is just another theoretical idea of no practical value, and consequently they may endeavor to demonstrate that it won't work under "practical" conditions.

Every furnace insulation project should be considered individually. The specific conditions involved should be studied and special treatment made accordingly. New furnaces may be fully insulated at the start, or old furnaces insulated step by step to overcome specific conditions. No single material as yet developed will meet all the conditions, so the problem of open hearth insulation offers an interesting field for development, with substantial economies to the plant which solves its individual problems in the most economic manner, balancing all factors involved and using the right kind of insulation in the correct amount and in the proper locations.

THE POURING OF MOLTEN STEEL

EFFORTS MADE TO PRODUCE SOUND INGOTS

By J. D. WALTERS, Open Hearth Superintendent
and E. G. HILL, Director of Research
LUKENS STEEL COMPANY

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania, September 24, 25, 26, 1935

▲ STATISTICS recently published show that the yield from steel ingots has a downward trend. A downward trend for yield is not conducive to sound sleep for the steel maker. As the yield goes down, pressure for better ingots immediately goes up, for the yield is the percentage of the raw ingots that is found in the finished product.

This trend may be attributed to more rigid specifications, and more critical inspection, but that doesn't help the open hearth man. What is wanted is higher yield, and so today we find him studying every angle of his practice, to see where he may eliminate defects. A large amount of his effort has been expended in trying to improve pouring practice.

Defects that have their origin attributed to bad pit practice are scabs, seams, snakes, pits, blisters, slivers, and laminations. In many cases the actual origin is hard to find, and the furnace practice, heating, and rolling are not entirely free from suspicion. Although there is a wide divergence of opinion as to the best methods to employ in casting ingots, all operators will agree that many defects are caused by running stoppers, splashing, improper rate of teeming, dirty ladles or molds, incorrect mold design, and contamination from refractories.

The following remarks describe some of the attempts that have been made to eliminate these sources of ingot defects, or to decrease costs by increasing the life of materials used. Asking the indulgence of any rolling mill men present, we will assume that the steel has been properly made in the open hearth.

TAPPING

The first step is to get the metal into the ladie in its best possible condition. Slow taps cause skulling around the ladle nozzle, which may result in a "sloppy" stream, running nozzle, and may also effect the final analysis of the metal. On the other hand, very rapid taps cause an early slag and a shortening of the time allowed for ladle additions.

LADLES

In general, ladles and ladle assembly have not changed greatly. The outstanding change in design has been the introduction of the oval ladle. This type has been the answer to the demand for larger capacity without the necessity of radical change in pit arrangement, cranes, and ladle stands. Its greater horizontal area is also favorable for the elimination of non-metallics from the molten metal.

J. D. WALTERS

E. G. HILL

Increased capacity without increase in weight has also been accomplished by the use of welded shells or tanks. By such construction the weight has been reduced approximately 25% and the strength materially increased. One company now has five 90 ton ladles so constructed.

The problem of lining life is ever present. It is accepted practice to line ladles with two courses of brick. The shell is first coated with fire clay and the tank lining laid against it. This course is smoothed over with fire clay and the inner course is then laid. Two types of inner course are used. The older system used a vertical brick, while the newer uses an arc shaped brick laid horizontally. Both are of course row locked. In order to assure tight joints the bricks are laid without mortar, but are dipped in a fire clay or high temperature cement slurry.

Considerable attention has been given to the density of ladle brick in order to prevent slag penetration. Attempts have been made to use a basic lining. The theory back of this is that a basic material would not react with the basic slag. This would in turn lengthen the lining life, produce cleaner steel, and prevent the loss of manganese and the reversion of phosphorous. So far these attempts have been unsatisfactory.

Insulation of the lining has been tried, although for the purpose of reducing the lining thickness in order to increase ladle capacity, rather than for the direct prevention of heat loss. Insulation has been accomplished by placing a 1″ to 1½″ of insulating cement between the tank and the regular lining.

An all welded oval shaped 85 ton ladle.

NOZZLES

Any money is well spent which actually prevents running nozzles or "fuzzy" streams. A well splashed ingot mold usually means a scabby product unless the splash is so light that it is "washed" off in the soaking pit.

In order to assure a perfect fit between nozzle and stopper, the stopper may be ground into place. To prevent nozzle cutting, harder burned nozzles have been used, and where the rate of teeming is regulated by the degree "opening up" very hard nozzles are being used. One maker of forging steels has greatly improved his product by such practice. Nozzles lined with magnesite and graphite have been tried.

In order to regulate the shape of the stream cross section and to prevent fanning, the length of the nozzle has been increased up to 12″. Where rectangular slab molds are used some operators have adopted nozzles with an oval shaped bore. This is for the purpose of preventing side splash and gouging. Recently a nozzle with the inner passage flared from a smaller upper diameter to a larger lower diameter has made its appearance.

There is no doubt that some one well versed in the laws of hydraulics should devote some time to the subject of nozzle design.

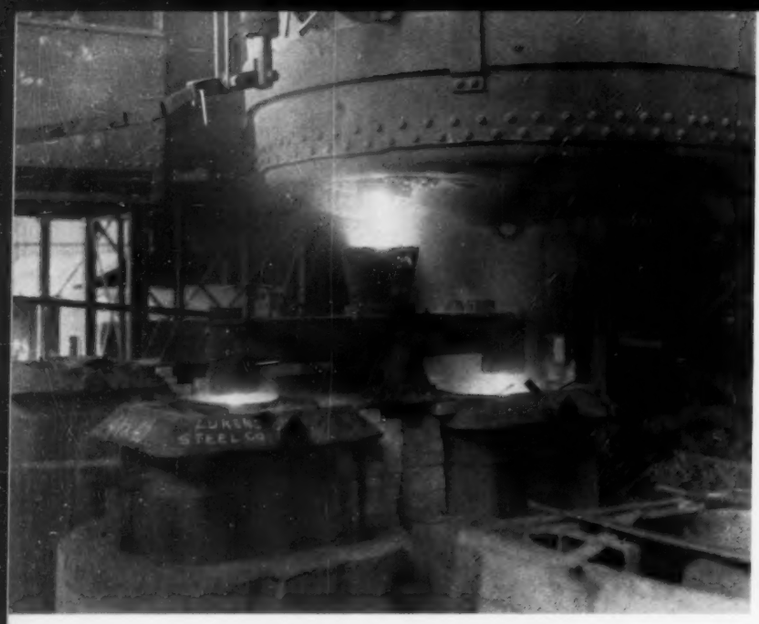
Little new is found in the design of stoppers and stopper rigging. Extreme care should be taken to assure a proper alignment of the stopper rod and the stopper head. Where used with pin and key assembly, stopper heads are now lined with fire clay to prevent contact of pin and graphite.

MOLDS

It has been recognized that mold design has a decided effect on the quality of the product. The question of mold design is also closely associated with mold life. The question of relation between ingot size and mold wall thickness has not been settled. Some authorities claim the mold wall thickness has but little effect on the ingot structure, while others claim a decided influence. The mold manufacturers have found a decided effect of mold thickness on mold life. and careful design has greatly increased mold life.

For quality killed steels the big end up mold has been widely adopted. This type of mold has also been recommended for rimming steel. For this type steel the upper portion of the mold should have a straight untapered section. Many operators favor corrugated molds, especially for killed steels. Others claim a lowering of mold life when this type is used. It undoubtedly does aid in preventing cracking.

Oval shaped ingots have been found to be very prone to roll into seamy products. The effect of corner radius and of camber on the side faces have been studied and at the plant where the writers are employed, it has been found necessary to establish a standard schedule for mold design. This is given in detail for those who may be interested.



Metal being poured in C and D Hot Top.

LUKENS STEEL COMPANY

Revised June 20, 1934

Slab-Ingot Contour and Design

ENDS OF INGOT

Thickness	Mill	Treatment
Up to 11⅞ inches	Both Universal & Plate Mill	Flat
12 inches to 13⅞"	Both Universal & Plate Mill	¼" rise.
14 inches to 17⅞"	Both Universal & Plate Mill	⅜" rise.
18 inches to 19⅞"	Both Universal & Plate Mill	½" rise.
20 inches to 22⅞"	Plate Mill only.	1½" rise.
23 inches to 25⅞"	Plate Mill only.	1¾" rise.
26 inches to 28⅞"	Plate Mill only.	2" rise.
29 inches to 31⅞"	Plate Mill only.	2¼" rise.
32 inches to 34⅞"	Plate Mill only.	2½" rise.
35 inches to 37⅞"	Plate Mill only.	2¾" rise.
38 inches to 40⅞"	Plate Mill only.	3" rise.

SIDES OF INGOT

Thickness	Treatment
Up to 25⅞ inches wide	No camber.
26 inches wide to 39⅞ inches wide	½ inch camber.
40 inches wide to 59⅞ inches wide	¾ inch camber.
60 inches wide to 90 inches wide.	1 inch camber.

CORNER RADIUS OF INGOT

7 inches to 9⅞ inches thick	1 inch radius.
10 inches to 14⅞ inches thick	1½ inches radius.
15 inches to 19⅞ inches thick	2 inches radius.
20 inches to 25⅞ inches thick	2½ inches radius.
26 inches to 30⅞ inches thick	3¼ inches radius.
31 inches to 35⅞ inches thick	4 inches radius.
36 inches to 40 inches thick and over	4¾ inches radius.

TAPER ON INGOT

Thickness—1 inch in 60 inches or less of length for all thickness (1/5"/ft.)

Width—1 inch in 60 inches or less of length for ingots up to 20⅞" in width.

¾ inches in 60 inches or less of length for ingots 21 inches to 39⅞" in width.

½ inch in 60 inches or less of length for ingot over 40 inches wide.

Increased proportionately for ingots over 60 inches long.

GENERAL

In redesigning molds according to this schedule, please note:

1. Mean area according to new design is to be held same as previous mean area.
2. On Universal Mill molds, hold present width and vary thickness to suit.
3. On Plate Mill molds, hold present thickness and vary width to suit.

DEFINITIONS

Thickness of ingot—Maximum dimension of short side at bottom end.

Width of Ingot—Maximum dimension of long side at bottom end.

Length of ingot—Total available length in ingot mold.

Rise on End and Camber on Side—One-half the amount of increase in thickness or width over what it would be if the ingot had flat sides and ends.

Taper on Ingot—Total change in thickness or width.

Cracked molds are to be avoided, but this must be approached with caution. Small checks and cracks may give small ridges on the ingot which are sweated off in soaking and which cause no defects in rolling. On the other hand if cracks are deep enough to cause binding of the ingot, cracking is almost sure to follow.

Gouges from stream cutting are far more dangerous than they appear. Rounded knobs should roll out well, but in many cases it will be found that the metal at such points is very porous and a defective surface may result.

One device that has proven successful in cutting down splashing and gouging is that of suspending "stove pipes" in the center of the molds. These cut away as the metal rises.

STOOLS AND BOTTOM PLATES

Stool design has been altered for two purposes.

1. To eliminate splashing.
2. To lengthen stool life.

Basins are now being cast into stools. These act as pouring basins which prevent side splash and the cutting of irregular depressions in the stool. On the bottom of the basin is placed a ½" to 1" steel disc and a ring of ¼" steel lines the side.

Recently much attention has been given to copper stools. The principle employed is that the copper will conduct the heat away so rapidly that little damage is done to the stool. It also increases the chilling rate of the lower part of the ingot. Advantages claimed for dished copper stools are:—

1. Longer stool life.
2. Elimination of cracking on the butt end of big end up ingots.
3. Reduction of the number of fins, scabs, "fish tails", and manufactured pipes in rimmed ingots.
4. Reduction of the amount of splashing.
5. Longer mold life.

C and D Hot Top in place.

On certain grades of steel however, the results have not been satisfactory. Some steels cut the copper much more rapidly than do others. Copper stools have been employed mainly for small ingots.

Bottom plates have been changed but little. Two companies use sectional bottom plates. These consist of four cast iron sections held in a welded or cast steel frame. This effects a saving of about 40% in weight and allows renewal of individual sections if necessary.

In bottom pouring another innovation is the placing of wooden boards over the runner outlets. These are cut to the shape of the ingot cross section. They prevent splashing during the early part of the pour. They gradually burn as the metal rises. In some set ups, boards are placed only in those molds which are known to be liable to splashing.

POURING TEMPERATURE

Pouring temperature is now closely controlled in most plants. The optical pyrometer is used for obtaining temperatures and charts with the rate of temperature drop per minute are used as a guide for the time of holding. Allowance must be made for slow taps.

The Fitterer thermocouple is now being used at a few plants. This allows for direct immersion of the elements, thus eliminating errors caused by emessivity and screening by fumes.

The correct pouring temperature varies for different steels. In bottom pouring practice the steel can not always be poured as cold as desired on account of the large number of molds per "set up". For killed steels the steel is poured as cold as possible without folding. High pouring temperatures promote cracking. For rimming heats the temperature depends on size and number of molds and on the carbon content.

Another factor that enters into holding for temperature is that of holding to aid in cleaning the steel from inclusions produced by late additions. Holding in the ladle too long may result in a running nozzle which will do far more harm than the holding would do good.

RATE OF POURING AND RATE OF RISE

Primarily the operator is interested in the rate at which the mold is filled. However, in some cases, the length of time the metal is in the ladle may be of prime importance. When a large number of ingots are to be poured, the number of shut offs may be important.

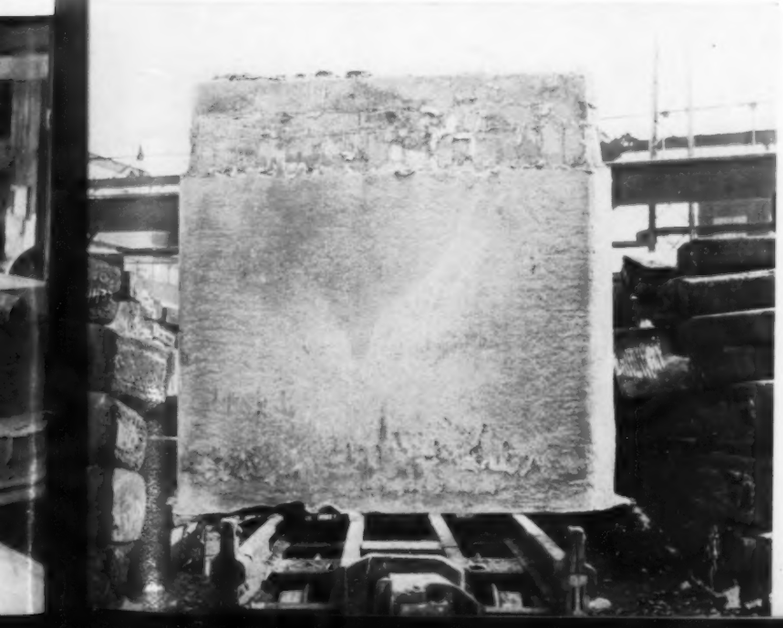
Time and again the rate of metal rise has been shown to have a marked effect on the ingot structure. This is especially true for rimming steel. Experience has shown that the optimum rate for one type of steel is not the best for others. For rimming steels, the writers believe a rate of rise of 9″ to 12″ per minute is the best. For killed steels they prefer 16″ to 20″ per minute. Semi-killed steels must have their rate of rise closely controlled according to the size ingot made.

Pouring at too slow a rate causes excessive folding. Too rapid a rate for killed steels promotes cracking and for rimmed steels it produces a porous zone just above the butt of the ingot.

The rate of rise is controlled by nozzle size, number of molds per bottom plate for bottom pouring, the use of box pouring, and by the degree of "opening up". Where the desire is to cut down the number of shut-offs and to empty the ladle quickly, multiple nozzles are used. At one plant a box with four nozzles is used. Both the molds and the box are shifted. Double nozzles are used in several plants.

C and D Hot Tops

A 90 x 28″ ingot weighing 57,000 lbs.



MOLD WASHES

Every operator has his favorite mold wash. Some have tried many. The type employed depends on the equipment available, pit set up, and personal taste. Washes used include tar, graphite, talc, asphalt lacquer, and carbon black. Where molds are rotated in regular cycles and equipment is suitable, dipping in hot tap is probably the most desirable. Where this cannot be done, spraying with graphite or other coating materials can be used. All agree that a clean warm mold is essential for a good surface. Wet cold molds produce seams, while dirty molds increase splashing and give porous surface.

HOT TOPS

Many types of hot tops are now in use. Several patented hot tops are on the market, but many operators still "build-in" their own. In the patented type the hot top is suspended and as soon as it is filled, the supports are knocked away. This allows a freedom of movement of the ingot which the built in type does

Lukens Hot Top in place. Mold on bottom plate.

not provide. Binding of the ingot by hot tops is a direct source of cracks.

Various materials are used to insulate the top of the metal such as lime, brick dust, straw, and diatomaceous earth. Patented compounds are also on the market. These are claimed to be heat producing as well as insulating.

STRIPPING

There is much difference in opinion as to the proper time the ingots should remain in the molds before stripping. For alloy steels, some operators recommend holding the ingots for as much as twenty hours. In the case of rimming steel, many strip the ingot as soon as possible. On large ingots care should be taken to allow the metal to solidify or internal defects will result. Quick stripping is favorable for long mold life.

This brief discussion has indicated some of the efforts made by steel makers to produce sound ingots. Not all problems have been solved, nor all defects eliminated, but there can be no doubt that as care on every detail of pit practice increases, the yield will go up, and conversely, the pressure from above will automatically go down.

Lukens Hot Top in place. Mold on bottom plate. Rings in place.

DISCUSSION

PRESENTED BY

J. A. CARTER, General Superintendent, Sharon Steel Hoop Co., Lowellville, Ohio

K. C. McCUTCHEON, Asst. Gen. Supt., American Rolling Mill Co., Ashland, Ky.

E. G. HILL, Director of Research, Lukens Steel Co., Coatesville, Pa.

J. A. Carter: Well, Mr. Hill, after all, we fellows in the open hearth and semi-finishing end do have a few details to watch at that, and it is surprising what fine material they make out of some of it. Are there any questions that we might ask Mr. Hill?

K. C. McCutcheon: I would like to ask Mr. Hill about asphalt lacquer. He mentioned using asphalt lacquer in ingot mold coatings. I wish he would explain that.

E. G. Hill: As far as I know this started in Germany. A paper was written on the subject and I believe it has been translated and printed. They use hard asphalt, and this is rather difficult to get into solution. We tried making some and had considerable difficulty in getting a good cheap solvent. The asphalt lacquer gives a very nice smooth surface, but I think most people who are using tar or graphite would find the use of this material out of the question as far as cost goes.

A Member: Do you recommend on your killed steel bottom cast 16 to 20 inches?

E. G. Hill: We don't bottom cast many killed steel ingots, but I know a plant not far from us that, at least for plates, will not cast ingots except by bottom pouring. So you have a difference of opinions. On the bottom pouring you have an additional cost for loss of metal, runners, and plate set-up. It is a question of cost as well as quality. If you can top cast and get away with it you are all right.

K. C. McCutcheon: Do I understand you top-cast 16 to 20 inches per minute killed steel?

E. G. Hill: Yes, between 16 and 20.

K. C. McCutcheon: That is in individual molds?

E. G. Hill: Yes, but you must remember we make rather large ingots. We make them up to 90 x 40″, so even with a good sized nozzle, the rate of rise is pretty slow.

A Member: What size nozzle do you use?

E. G. Hill: For the larger furnaces, a 1¾″ nozzle.

USE OF THE VENTURI PORT

ITS DESIGN, CONSTRUCTION AND OPERATION

By GEORGE L. DANFORTH, JR., Pres.
Open Hearth Combustion Co.
CHICAGO, ILLINOIS

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania, September 24, 25; 26, 1935

▲ THE AUTHOR has had the privilege of being closely associated with a number of major improvements accomplished in the past twenty-five years in connection with the construction and operation of open hearth furnaces. These improvements include waste heat boilers, more efficient regenerators, the Naismith sloping back wall, the damper controlled port, and the venturi port.

The purpose of this paper is to describe the design, construction and operation of the venturi port and the results accomplished therewith in comparison with the orthodox ports previously used and with the damper controlled ports which were conceived and to considerable extent developed at approximately the same time the venturi port was being put into successful use.

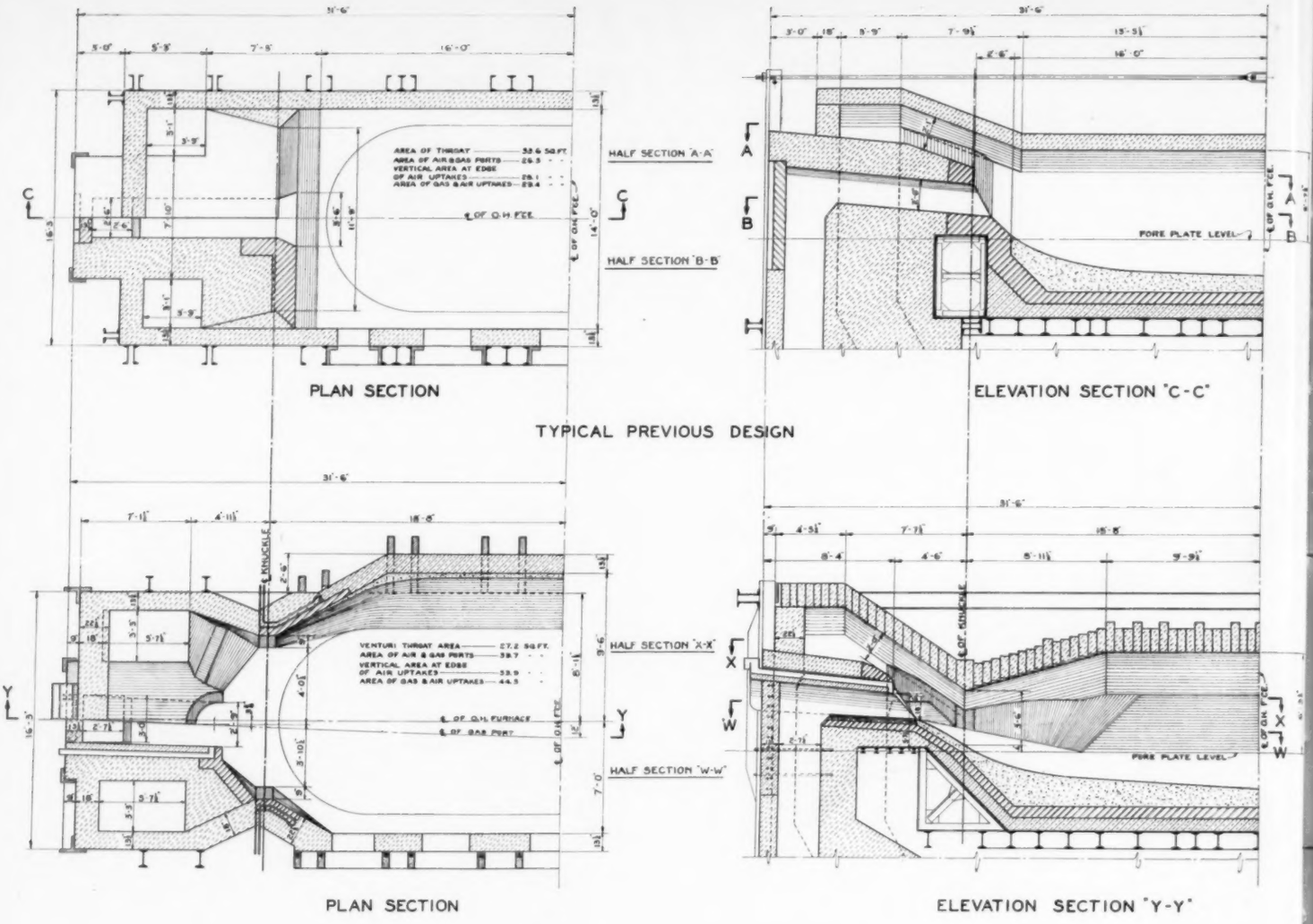
It has long been realized by the open hearth fraternity that the port is a very important, possibly the most important, part of the open hearth furnace, for on it depends the introduction of the fuel and air, the character and control of the flame developed in the melting chamber, and the exhaust of the products of combustion. It has likewise been recognized that a port construction best designed for introducing and mixing the fuel and air is not the best for meeting the outgoing conditions, including the destructiveness of the outgoing gases, sometimes at excessive temperature, and laden with dust and fumes highly detrimental to the brick work of the outgoing port.

The function of the incoming port is to introduce the air and fuel in such a manner that the two are quickly mixed to produce rapid combustion with a short, hot flame, controlled to concentrate on the materials to be melted and refined, and kept as far as possible from contact with the adjacent brick work. This suggests a port having passageways of relatively small area to give high velocity and direction to the incoming fuel and air, *but* the requirement of the outgoing port is to provide an exit for the exhaust gases with a minimum resistance to their flow and with a minimum destruction of the port, and this suggests a port of large area through which the waste gases may exhaust with low velocity. It is therefore no wonder that a number of differently designed ports have been used in the endeavor to effect the most satisfactory compromise between the incoming and outgoing conditions.

GEORGE L. DANFORTH, JR.

It is obvious that only a few of the many port designs previously used can be shown and discussed in this paper. The drawings accompanying this paper show ports typical of previous design, one for producer gas, one for natural gas, and one for liquid fuel, in comparison with the venturi port designs used for the several fuels mentioned.

It will be noted by the drawings of Figure No. 1, that the port typical of previous designs for producer gas has the monkey walls located in the air port entirely above the gas port, with their apexes in line with the mouth of the gas port and considerably removed from the junction of the port slope with the furnace roof. This restriction in the air port is intended to increase the velocity of the air, in order to drive it into mixture with the fuel in the combustion and melting chamber, for there is no mixing chamber provided between the gas and air ports and the melting chamber, and the vertical area at this point is considerably



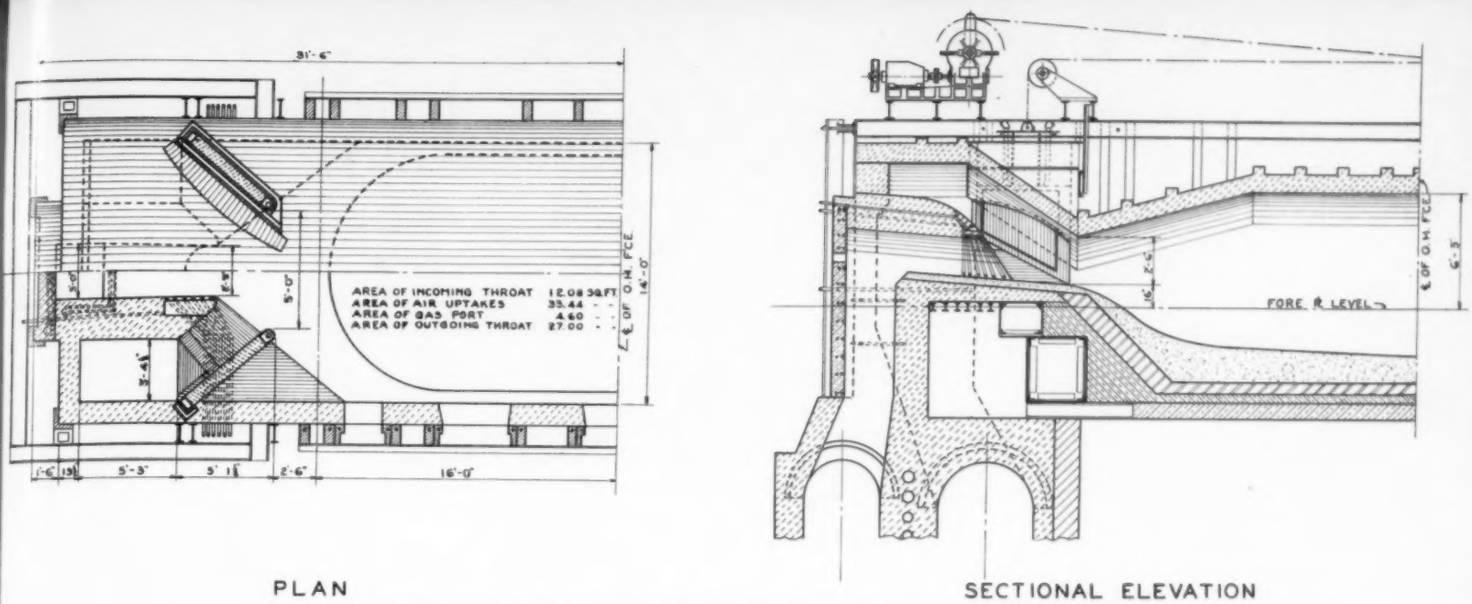
(Fig. 1)—**VENTURI DESIGN**

PRODUCER GAS FIRED OPEN HEARTH FURNACE

greater than that of the gas and air ports and than that of the gas and air uptakes. With this general arrangement, the mixture of the fuel and air is made entirely in the melting chamber, is not as rapid as desired, and results in a long flame deficient in temperature on the incoming end of the furnace hearth and excessively hot adjacent the outgoing port. Furthermore, the restriction in the air port is usually not as far distant from the end wall of the port as is shown in this drawing, and the high velocity of the hot waste gases passing through this restriction, coupled with the choking effect of the small downtakes connecting the port to the slag pocket, is excessively damaging to the end wall and the adjacent brick work, as well as to the furnace draft.

In recognition of the difference in the requirement of the incoming port compared with that of the outgoing port, the damper controlled port, as shown in Figure 2, was devised to restrict the area when functioning as the incoming port and to open up this area when functioning on the outgoing end of the furnace. This was accomplished by inserting restricting water-cooled brick lined dampers into the incoming port, and withdrawing them from the outgoing port. This required a considerable amount of equipment, which in addition to the first cost for installation, imposed a constant expense for maintenance and the heat losses due to the use of the unusual amount of cooling water. These disadvantages largely offset the advantages gained.

The object of the venturi port invention, Patent No. 1,647,213, was to provide a port which when functioning as the incoming port, would mix the air and fuel as rapidly as desired, to produce a shorter, hotter, and better directed flame which would accomplish its melting and refining work before reaching the outgoing end of the melting chamber, with consequently less damage to the outgoing port and end wall, and with no impairment to the furnace draft; and without the disadvantages of water-cooled dampers. This has been accomplished with a port construction comprising short fuel and air passageways, each having

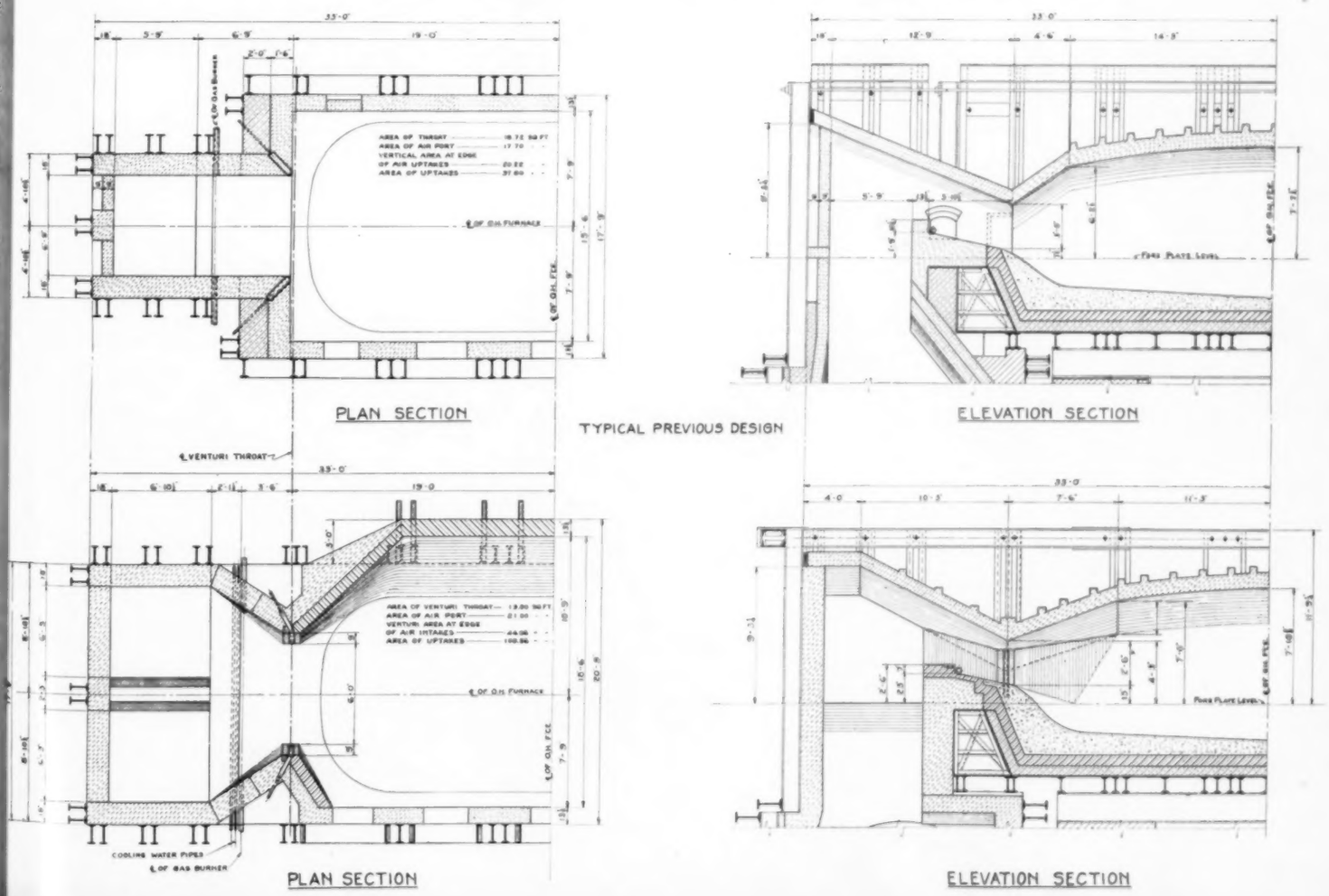

AREA OF INCOMING THROAT 12.08 SQ FT
AREA OF AIR UPTAKES 33.44 " "
AREA OF GAS PORT 4.60 " "
AREA OF OUTGOING THROAT 27.00 " "
℄ OF O.H. FCE
FORE R LEVEL
PLAN
SECTIONAL ELEVATION

(Fig. 2)—**PRODUCER GAS FIRED DAMPER TYPE PORT OPEN HEARTH FURNACE**

a relatively large area adjacent its end wall, gradually decreasing in area and merging into a common passageway or mixing chamber having a throat of relatively small area connecting with the end of the melting chamber, the end of the melting chamber being contracted at its junction with the throat and then gradually expanded to its normal area.

The eminent scientist Venturi was the first to call attention, in the year 1796, to the fact that when a fluid is passed through a conduit having a relatively short section gradually contracted and then gradually expanded in area, the normal pressure of the fluid is reduced in this section to a correspondingly higher velocity and then restored with a very minor loss. This law is employed in the construction of the venturi meter, invented by Clemens Herchel, and the so-called venturi port arrangement as just described provides a similar section extending from the end wall of the furnace to well within the melting chamber. This permits the use of the small port desired for incoming

(Fig. 3)—**VENTURI DESIGN—NATURAL GAS FIRED OPEN HEARTH FURNACE**



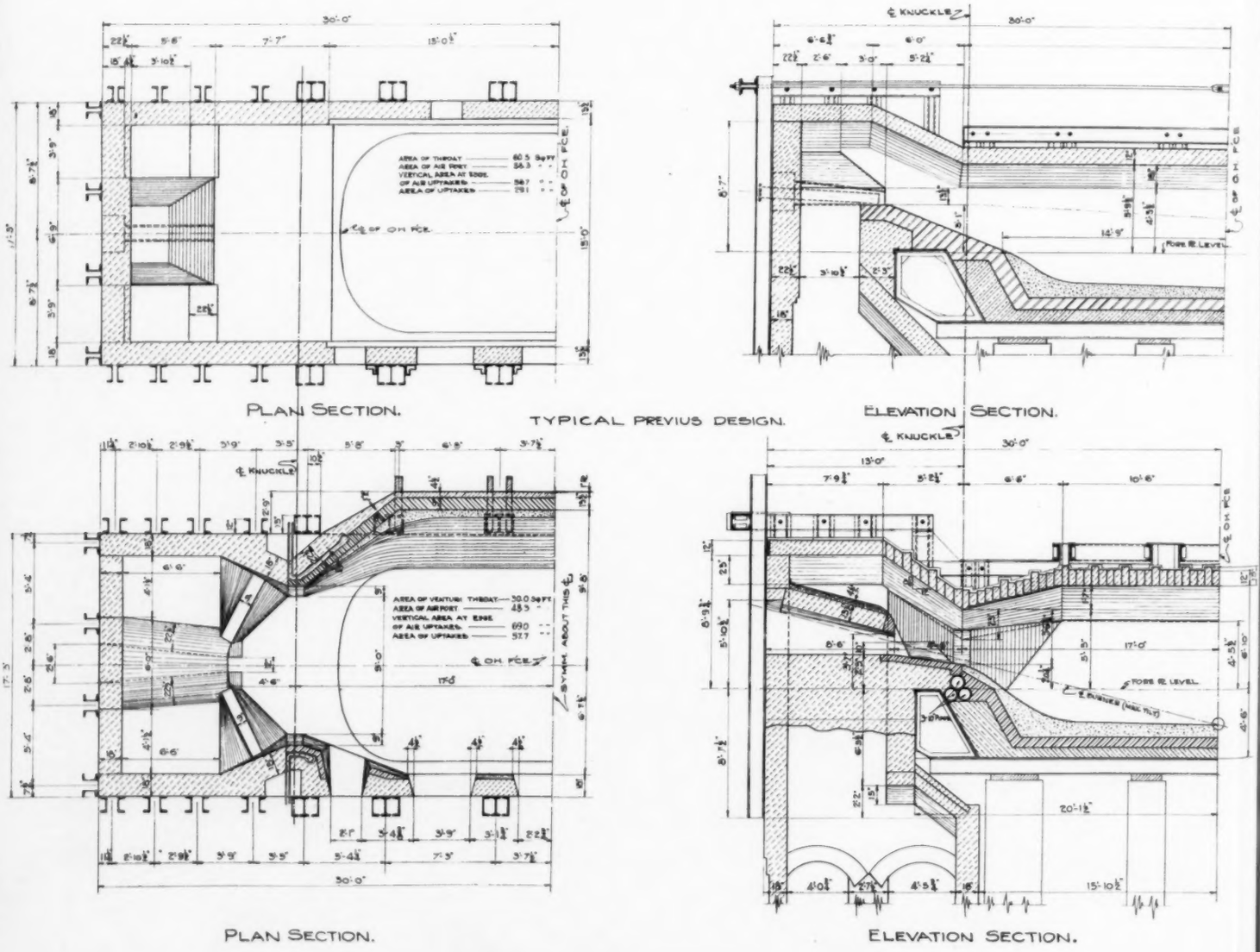
purposes without materially retarding the passage of the waste gases through the outgoing port. To further assist the exhaust of the waste gases and to further minimize their damaging effect on the adjacent brick work, the downtakes connecting the ports to the slag pockets are made considerably larger in the venturi design than was customary with previous designs. So in the operation of a producer gas fired furnace equipped with venturi ports, the incoming streams of air and fuel are gradually reduced in area with a corresponding increase in velocity and mixed in the mixing chamber, then gradually expanded and consumed in the combustion or melting chamber; the products of combustion are then gradually contracted and exhausted with high velocity through the outgoing throat, then gradually expanded and reduced in velocity while passing through the outgoing port, with less impingement on the end walls and adjacent brick work, and with a minimized resistance to their flow.

It may be noted by the drawings in Figure No. 3 that the venturi port, when designed for the use of natural gas, provides a smaller throat for introducing the air and gas and a wider downtake for exhausting the waste gases than were permissible in the previous construction for the use of such fuel. Inasmuch as the development and direction of the natural gas flame are very dependent on a high velocity flow of the air, the smaller throat is of material assistance in these respects, while the larger downtake not only assists in making the smaller port permissible, but also reduces the velocity of the outgoing gases at this point and minimizes the damage to the adjacent end wall.

The venturi design, when used with liquid fuel (Figure No. 4) affords the smaller throat and larger downtake with the advantages much the same as with producer and natural gas, excepting that with liquid fuel the direction of the flame is not so dependent on the flow of the air, for the velocity of the liquid fuel stream is of material assistance in this respect. Nevertheless, the smaller throat gives a more rapid mixture of the air and fuel, resulting in the shorter, hotter and more concentrated flame. This reduces the fuel con-

(Fig. 4)—VENTURI DESIGN

OIL FIRED OPEN HEARTH FURNACE



sumption per ton of steel produced and coupled with the large downtake area, greatly minimizes the damage done to the end walls by the outgoing products of combustion. Furthermore, the shorter, hotter flame, being more active on the incoming end of the melting chamber, reduces the carry-over of oxides etc. which is usually greater with the liquid fuel than when gas fuel is used.

The author has previously mentioned that the disadvantages of the damper controlled ports offset largely the advantages obtained with this type of port. From this it might be inferred that the use of such ports is not justified. This is not true with special conditions such as prevail with the use of a mixed fuel comprised of blast furnace and coke oven gas. There is also a combination of the damper-controlled and venturi port constructions devised for the use of such mixed fuel and now in successful use on a number of furnaces in the open hearth plant of a leading steel producing company.

The volume of a mixed gas consisting of substantially two-thirds blast furnace gas and one-third coke oven gas is approximately equal to that of the producer gas required for the same purpose. Therefore, for incoming purposes the mouths of the gas ports for the two fuels must be of about equal area, approximating 4 sq. ft. in a furnace tapping 125 to 150 tons per heat. This area is much less than that of the air ports, and while it does permit a sufficient portion of the hot products of combustion to pass to the gas regenerator to properly preheat producer gas which enters the regenerator at a temperature averaging 1000 to 1200° F., this portion is not sufficient for properly preheating the mixed gas which enters the regenerator at but little more than atmospheric temperature.

In the damper controlled—venturi combination for mixed gas, the venturi-like mixing chamber and throat direct the incoming air into proper mixture with the fuel and do not impair the exhaustion of the waste gases on the outgoing end of the furnace. The movable gas port on the incoming end of the furnace is in its inward position and provides the necessary gas port of about 4 sq. ft., while on the outgoing end it is withdrawn to afford a free movement of the waste gases to the central downtake leading to the gas regenerator, the area of this downtake being greater than the 4 sq. ft. of the gas port, and thus permits a much greater portion of the hot waste gases to pass to the gas regenerator. This combination is covered by several patents granted individually to Mr. George E. Rose and the Author.

A very large number of open hearth furnaces are now equipped with the venturi port, with a notable increase in production and decrease in the expense for labor, fuel, and furnace maintenance. This improvement amounts to from 10 to 15%, varying with the type of venturi port used and the relative merit of the port design displaced. At one large steel company having a number of modern producer gas furnaces equipped with venturi ports, the production is in excess of two thousand tons per week per furnace, with a fuel consumption of less than four hundred pounds of Elkhorn coal per ton of ingots, and with a cost above net metal of from $3.00 to $3.25, despite the fact that the coal cost is $5.75 per gross ton, delivered to the works. It has also been demonstrated that even with a cheaper grade of materials in the furnace charge, the furnace construction affording the best combustion control will produce the better quality of steel, and it is generally recognized that with the conditions which prevail today, the producer of steel products must produce the highest quality at the minimum cost, and that the venturi port is of material aid in the accomplishment of these results.

DISCUSSION

PRESENTED BY

J. A. CARTER, General Superintendent, Sharon Steel Hoop Co., Lowellville, Ohio

G. E. ROSE, General Superintendent, Wisconsin Steel Works, International Harvester Co., South Chicago, Ill.

W. C. KITTO, Open Hearth Superintendent, Pittsburgh Steel Co., Monessen, Pa.

J. A. Carter: Are there any questions we can put to Mr. Danforth covering this paper? Do any of you use the venturi port?

G. E. Rose: In answer to your question, I would report that we use them at Wisconsin Steel Works—I don't know whether I should say venturi ports or rather venturi side-wall construction with a movable port.

I should think that most of the questions today might naturally come from other districts than the Chicago District. We have been very closely associated and in contact with the author of this paper, Mr. Danforth. I think there is no question but that he, in his advocacy of the venturi furnace construction, has made a wonderful improvement in open hearth practice wherever his ideas have been put into effect.

We have presented a paper which was published in the January 1936 issue of the Iron and Steel Engineer, giving some data as to our open hearth furnace performance with the use of venturi side-wall construction in conjunction with the movable port and with mixed gas fuel, i.e., blast furnace and coke oven gas in proportions about as Mr. Danforth has mentioned.

As I said in the first place, I think perhaps more questions should come from districts that perhaps have not put into practice in the open hearth departments the venturi construction as much as we have in the Chicago district.

W. C. Kitto: I don't have much to say. I think it is a big improvement over the old construction for producer gas. You get a better control of your flame and I think it does help in the quality of your steel. I think it is a step in the right direction.

ROOF TEMPERATURE CONTROL

FOR USE IN OPEN HEARTH FURNACES

By M. J. BRADLEY, Engineer
Leeds & Northrup Company
PHILADELPHIA, PENNSYLVANIA

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pa., September 24, 25, 26, 1935

▲ THE ART of measuring temperatures in open hearth roofs has advanced rapidly during the last few years. This is due to an increasing demand from the operators to have a continuous record of the roof temperatures during all stages of the heat, especially on insulated roofs. It has been made possible in a great measure, by the development of the radiation type of temperature measuring equipment. These units do not have to be installed in contact with the hot surface, but are capable of measuring temperatures at reasonable distances from the hot body. Therefore, they do not have to withstand the high temperatures encountered in open hearth roofs. In fact, when measuring temperatures around 3000° F., the temperature measuring element seldom heats up beyond 250° F. Thus they are not subjected to actual temperatures like the thermocouple type of equipment. This minimizes the maintenance attention required once the unit is properly installed and put into operation. With equipment available for measuring roof temperatures the problem then revolves itself around what temperature should be measured.

M. J. BRADLEY

ROOF TEMPERATURES

Experience has demonstrated that temperatures taken on the outer surface of the furnace roof brick or between the brick and the insulation are of little value. The heat lag through the roof brick is so great that destructive temperatures may persist on the inside surface of the roof for long periods before any indication is noted on the outer surface. It requires a sustained high temperature to cause severe damage or stringers to the roof because the melting point of the brick does not take place at a definite temperature but occurs over a temperature range. It is a product of a time-temperature effect in which the brick passes gradually through a softening stage. The higher the temperature of the roof mass, the shorter the time required. Most destruction to the roof occurs during the working and finishing stages of the heat because of the higher temperature of the roof mass. However, a great deal of damage may occur during the melting down stage, especially if a pile of scrap deflects the flame directly against the roof. Another type of roof destruction, more pronounced on producer gas fired furnace, occurs without stringers being formed. It is due to "sweating" or melting of the iron oxide-silica mixture on the skin surface of the roof brick. This fused layer is removed continuously by the erosive action of the waste gases and entrained solid particles.

The heat penetration or "soaking" temperature of the brick is the most important when considering roof protection. When a new roof is started into operation the inside surface heating up first causes the silica brick to pass through certain physical and chemical changes. The original quartz structure is stable below 1598° F. Between 1598° F. and 2678° F. the tridymite modification exists while above 2678° F. to the melting temperature of around 3110° F. the cristobalite modification is stable. Thus, when the roof is under operating conditions the inside skin surface of the brick glazes over with a layer of mixed silicates, the next section consists of the cristobalite modification, the following section of the tridymite modification, and finally the top sec-

tion consists of the original quartz structure. The extent of these various sections is determined by the operating temperatures and is greatly influenced by the presence or absence of roof insulation[1-2]. In general it may be stated that the cristobalite and tridymite areas are much thicker on roofs which are insulated. It might be worth mentioning that vapors of iron oxide, manganese, sulphur, etc., penetrate and are more concentrated in the cristobalite area. Due to the differences in the coefficient of expansion and contraction of these compounds on heating and cooling, greater strains are set up in the cristobalite area or the zone in the neighborhood of the cristobalite and tridymite modifications. This may, in part, explain the presence of cracks or cleavage planes found frequently in this same area. In Figure No. 1 a crack can be seen extending almost across the width of the brick. It is in this same region that the "soaking" temperatures are taken in Open Hearth roofs.

ROOF LOCATIONS

A great deal of experimental study has been carried out in order to determine the best location in which to measure the "soaking" temperature in the roof. Multiple installations demonstrated that it is practically impossible to measure the "soaking" temperature throughout the roof area. It also demonstrated that the hottest areas during one heat were not necessarily the hottest areas during the following heat. Consequently one installation in the center of the roof has been adopted generally. It was found that this location has an analogous relationship to both ends of the furnace, certainly when the regenerative systems are kept in balance and the furnace is reversed automatically by the temperature difference method. The "soaking" temperature of this location may be used as a relative guide to protect the hotter areas, such as over the tap hole, along the back wall, or the outgoing end. This is due to the fact that the inside roof surface tends to become uniform in temperature from flame radiation unless the flame impinges directly on some local spot.

A special Carbofrax block, which has a heat conductivity six to eight times that of silica roof brick, has been developed in order to obtain a rapid temperature response. The block has a tapered hole extending within one inch from the bottom and is provided with flanges at the top to prevent it from slipping down below the adjacent roof brick. The external dimensions are such as to permit it to be installed in the place of two standard roof bricks. It is more convenient to install when a new roof is being built but it can be installed after the furnace has been in operation. Special Carbofrax powder is used to build up the bottom of the block periodically as the roof structure wears thinner. This procedure permits the block to give satisfactory operation throughout the life of the furnace roof.

1—Effect of Insulation on the Silica Refractories of an Open Hearth Steel Furnace Crown—L. B. Miller—Paper presented at Buffalo Meeting Amer. Cer. Society, Feb. 1935.

2—Comparison of Used Silica Brick from Insulated and Uninsulated Basic Open Hearth Roofs—F. A. Harvey—Journal Amer. Cer. Soc. Vol. 18, No. 3, March 1935.

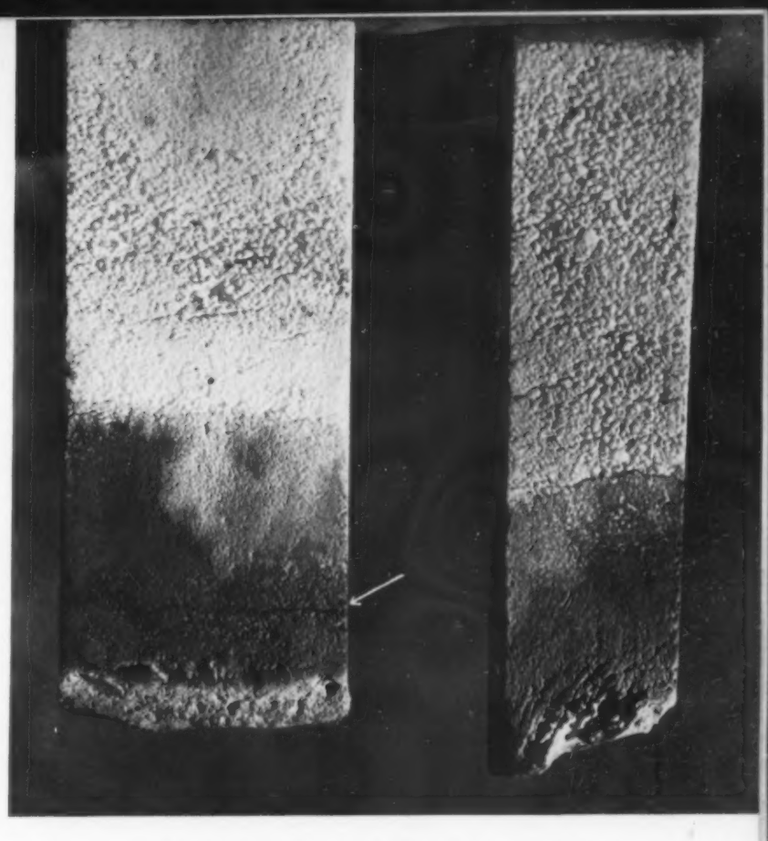


Fig. 1—Two silica brick after being removed from the roof of a basic open hearth roof.

ROOF INSTALLATION

The temperature measuring device (Thermotube) is installed in a water cooling jacket which rests on the top of the Carbofrax block. The cooling jacket is definitely lined up and held into position with respect to the block so that any shifting of the roof structure does not affect the relation between the sighting block and the thermotube. Provision is also made to prevent the equipment from being destroyed should this section of the roof fall into the furnace. On the majority of the installations a walkway is mounted on the furnace buckstays and tie rods so that it is possible to inspect the installation when the furnace is in operation without stepping on brick roof. A typical installation is shown in Figure No. 2. The indicating and recording controller is usually mounted across the charging floor in a position that it can be seen easily from any location in front of the furnace.

ROOF CONTROL

The temperature control point is usually set from 80 to 100° F. lower on a new roof when the furnace is started into operation. This is to prevent the brickwork from being seriously overheated during the seasoning stage. It also permits the silica roof brick to change over slowly into its stable modification. After the first few heats have been made the roof becomes seasoned and the temperature control point may be raised to its safe maximum limit. The safe temperature control limit (much above which the roof begins to string) varies somewhat in different shops but is generally in the neighborhood of 3000° F.

The usual open hearth practice, after the scrap is charged, is to burn the maximum amount of fuel that

can be burned efficiently in the furnace. During the melting down stage the temperature differential between the flame and the scrap is such that the greater part of the heat is absorbed by the scrap. Also because of the flame impingement on the cold scrap, the flame temperature is much lower than it is after the bath is under cover. However, even under these conditions it may be possible for the surface of the roof brick to be heated higher than the softening point but due to the heat soaking into the brick very little damage seldom occurs except as mentioned above when the flame actually impinges on a local area in the roof.

Fig. 2—Temperature measuring equipment installed on an open hearth roof. Thermotube is raised to show carbafrox block.

This can be avoided by an even distribution of the scrap. It is during the melting down stage that time may be saved in making the heat.

The heat head in the furnace increases rapidly after the bath is under cover. The whole furnace structure attains a high temperature and the heat soaks into the brickwork. During the lime boil, especially when most of the lime is up, the roof becomes very hot and may string readily unless the fuel is reduced. It is generally at this stage in the heat that the roof control automatically cuts back on the fuel. On some installations the control cuts the fuel off entirely. This allows the furnace structure to cool rapidly; when the temperature has dropped to a safe limit the fuel is turned on again automatically. The operators using this method claim that the fuel going off entirely readily attracts the first helper's attention to the fact that he has been carrying too much fuel on the furnace. Of course, if the furnace is equipped with combustion control both fuel and air are cut off.

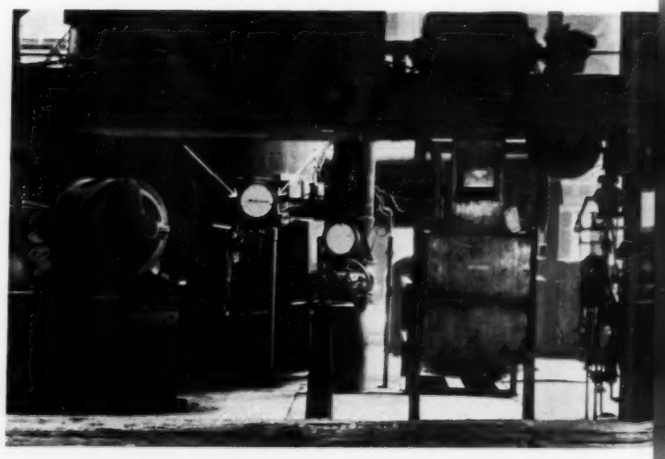
The fuel is only partially cut off on the majority of the installations. For instance, on furnaces being fired with coke gas and tar, only the coke gas is cut off; when oil is used, only a part of the oil sufficient to lower the temperature to a safe limit is cut off; on producer gas fired furnaces, the steam is cut back at the gas producer, etc., etc. It is agreed, generally, that the first helper should regulate the fuel so that the temperature remains as close to the maximum working limit as possible without cutting off automatically. The fluctu ating fuel and temperature conditions are not the best suited for furnace operation. As the temperature indicator can be seen easily from across the charging floor (see Figure 3) the first helper may use it as a guide for fuel regulation. He soon becomes adept at holding the temperature close to the working maximum without permitting the control to cut back the fuel. However, if he is engaged in other details, such as preparing for tapping, the control will continue to cut the fuel, if necessary to reduce the temperature, and thus protect the roof until the operator does reduce the fuel.

It is possible to install a full-balancing control mechanism on the fuel supply so that the fuel may be regulated automatically in small increments. This method allows the control to increase the fuel as well as decrease it and permits holding the temperature at the set value without manual assistance.

ROOF CONTROL RECORD

The indicating and recording controller not only furnishes a continuous indication for the guidance of the first helper, but it also furnishes a continuous record of the operating temperatures throughout the heat. This record enables the superintendent to see how the furnace has been operated during each heat. It supplies a record of each first helper's management of the

Fig. 3—An Indicating and Recording Controller



furnace. The record also demonstrates the sensitivity, response and reliability of the temperature measuring equipment.

A typical record of two heats made in a 100-ton, basic, open hearth furnace is shown in Figure 4. The two heats were low carbon steel of the same specifications. An analysis of this record shows rather clearly how different first helpers run the same furnace. Starting with the day shift, at 8:00 A.M. first helper "A" took charge of the furnace after the bottom had been made up ready for charging. The charging was completed before 9:00 A.M. The fuel was then increased so that the temperature increased steadily until it

reached 2900° F. around 10:00 A.M. It remained rather close to this value until the hot metal addition at 11:00 A.M. This caused a slight decrease in temperature which gradually increased as the lime came up and reached 3000° F. at 2:00 P.M., at which time the lime was practically all up. It may be observed that the operator did not permit the furnace to become too hot before the addition; however, he might possibly have raised the temperature more rapidly after the addition of the hot metal. From 2:00 to 3:00 P.M. the temperature was very close to the control point. In fact, the control cut the fuel back once at 3:00 P.M. The first helper apparently noticed the control action and reduced the fuel slightly so that the temperature remained just below the set limit and the control did not operate again during his turn. This record shows that first helper "A" drove the furnace very steadily close to its maximum temperature limit except for a couple of hours after the hot metal addition. In fact, it shows good furnace operation. The steady, sustained operation speeded up the heat so that it was tapped eight hours and fifteen minutes after finishing charging.

First helper "B" took charge of the furnace at 4:00 P.M. He apparently looked into the furnace and decided to give it more fuel. He increased the fuel too much and the control cut it back a few minutes later. When he reduced the fuel, to drop the temperature before tapping, he again cut back too much and the temperature dropped over 100° F. A few minutes later he again increased the fuel and tapped the heat shortly afterwards at 5:10 P.M.

The bottom was made up and charging finished shortly before 7:00 P.M. Apparently first helper "B" used more fuel during the melting down stage because the temperature built up much more rapidly and just before 8:00 P.M. it approached 3000° F. Obviously he was preparing for the heavy cold pig charge which was added a little before 8:00 P.M. This dropped the temperature around 400° F. and it did not build up again quite as rapidly as previously. However, he did drive the furnace so that it was up to temperature and the hot metal added just before 10:00 P.M., which was two hours after the cold pig charge. It may be noted that the cold pig charge slowed up this heat about one hour. Or, in other words, the hot metal addition took place three hours after charging while in the previous heat only two hours elapsed between finishing charging and the addition of the hot metal. Although the temperature was about 25° F. higher when the hot metal was added, the temperature drop was greater than in the previous heat. However, due to difference in furnace operation this heat loss was recovered in approximately one-half the time it required on the previous heat. The operator had the furnace heated up close to set limit about one-half hour before turning it over to the succeeding shift at 12:00 midnight. Apparently he reduced the fuel just before going to wash up.

The record shows plainly the effects of the cold pig charge on furnace operation. It also shows that first helper "B" drove the furnace harder than first helper "A", especially during melting down. However, he did not keep the heat head building up progressively and allowed the heat to chill too much after the addition of the hot metal.

First helper "C" took charge of the furnace a few minutes before 12:00 midnight. It is difficult to analyze correctly the temperature record for the first five hours of this shift without having a complete record of facts. We can imagine an enthusiastic salesman pointing to such a record as absolute proof that the first helper neglected the furnace, even took a nap, while the control continued to protect the furnace roof by cutting back repeatedly the fuel. We are inclined to believe, however, that when "C" inspected the furnace he was far from being pleased at the condition of the heat. Undoubtedly the bath was cold and covered with a thick heavy slag which deflected the heat up against the roof, because he immediately increased the fuel to heat up the bath. This increase in fuel caused the

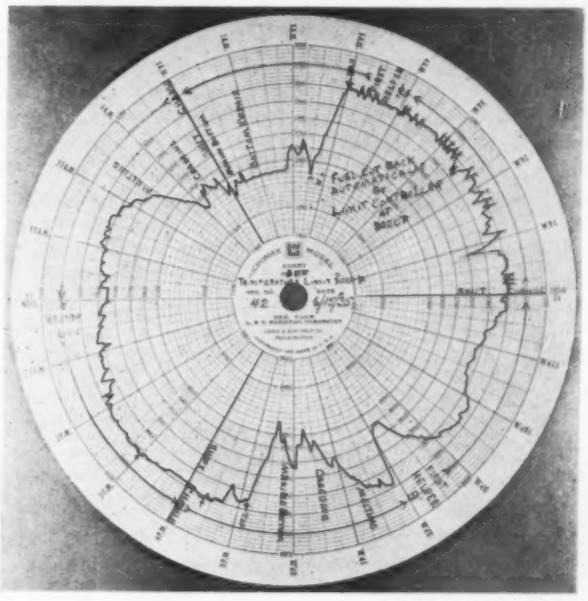


Fig. 4—A typical temperature record chart

roof to heat up rapidly and the control cut back three times in succession without any change in fuel volume by the first helper. He then lowered the fuel supply so that the temperature straightened out just below the maximum set point for the next half hour. At 12:45 P.M. the fuel was cut off and an addition made to the bath. This permitted the temperature to drop around 200° F. but built back rapidly and the control cut the fuel back about fifteen minutes later. At this time the fuel was again reduced by the first helper and the temperature remained considerably below the set limit during the next half-hour. The fuel was again increased and during the following hour the control operated five or six times. Around 2:30 A.M. another addition was made to the bath and the fuel regulated so that temperature of the roof tended rapidly to raise above the control setting and the control cut the fuel off and on approximately every five minutes until the first helper reduced it at 3:10 A.M. Usually the first helper would have reduced the fuel at the first control action but in this instance he undoubtedly was trying to pound heat into the bath and realized that the control would pre-

vent the roof from being damaged. This method of operation was continued right up to the time the heat was tapped at 5:00 A.M. In spite of the fact that the operator, by simply throwing a switch, could have made the control inoperative. He then could have increased the fuel supply as much as he wished but would have had to assume the responsibility of possible roof damage. There is no evidence that the furnace was cooled before tapping as in the previous heat. This indicates that due to melting and slag conditions first helper "C" had considerable difficulty in getting the bath hot enough for working and tapping.

It is interesting to note the differences in the two heats. First helper "A" regulated the fuel so that during the melting down stage the whole furnace system built up in heat head continuously and he kept it increasing without any setbacks until the temperature was dropped before tapping. The heat was tapped in approximately three hours after the lime was up. The second heat was forced much harder from the very start. It melted down much quicker with probably less heat head in the bath; it was chilled by the cold pig charge, and allowed to chill too much again after the hot metal charge. These conditions were responsible in a great measure for the battle "C" put up in order to get the heat out. It required over five hours after the lime was up before the heat was tapped. This method of operation is much more destructive on refractories, requires considerably more fuel per ton of steel produced, and actually resulted in a decrease of 2.5 tons per hour compared to the first heat.

ROOF CONTROL SUMMARY

A great many roof temperature controls are in operation on open hearth furnaces. The majority of these are operating from the "Soaking" temperature measured approximately one inch from the inside surface of the roof. The equipment used is designed especially for this application and many units have been in operation over two years. To date, not a single thermotube has been returned for repair, nor has any unit been destroyed due to roof failure.

The maintenance required on roof temperature control equipment is exceedingly small. It takes from five to ten minutes daily of one man's time to change the charts, add ink to the pen and make occasional inspection and checking. In terms of dollars and cents the maintenance cost runs in the neighborhood of seven thousandths of one cent per ton of steel produced.

On insulated furnaces, the first helper has a tendency to play safe, and so operates the furnace at a lower temperature in order to protect the roof. However, the protection afforded by roof temperature control enables him to run the furnace close to the maximum safe temperature continuously, which results in a shortening in the time of heats and an increase in production per hour. In some cases this improvement has resulted in an increase around twelve percent in production per hour and an increase of around fifteen percent in length of roof life over the previous campaigns. Similar results have been reported from installations on uninsulated open hearth roofs.

DISCUSSION

PRESENTED BY

J. A. CARTER, General Supt., Sharon Steel Hoop Company, Lowellville, Ohio

K. C. McCUTCHEON, Asst. Gen. Supt., American Rolling Mill Company, Ashland, Ky.

L. A. DEESZ, Combustion Engineer, Republic Steel Corporation, Youngstown, Ohio

M. J. BRADLEY, Market Extension Division, Leeds and Northrup Company, Philadelphia, Pa.

E. W. HILL, Supt. O. H. No. 4, Carnegie-Illinois Steel Corp., Homestead, Pa.

M. J. CONWAY, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.

GILBERT SOLER, Director of Research, Timken Steel and Tube Company, Canton, Ohio

Chairman Carter: Mr. Bradley, may I ask you a question? Where do you prefer to locate your thermocouple on the roof?

M. J. Bradley: It is installed approximately in the center of the roof, a short distance back of the midposition, towards the back. It is not in the hottest part directly over the tapping hole, but possibly half way between the center of the roof and the back wall.

Chairman Carter: Mr. McCutcheon, do you have any comments to make?

K. C. McCutcheon: I want to ask Mr. Bradley if they have any difficulty in maintaining the roof where the temperature element is located. That point does not fail sooner than the rest of it? In other words, it doesn't have to be patched around the element?

M. J. Bradley: We have found that when the carbofrax block is put into a hot roof there is some tendency for the silica brick to spall near the edges of the carbofrax block. The spalling, however, has never been sufficient to weaken the roof structure. When the block is built in with the new roof no spalling occurs. We have no evidence that roof installations have weakened the roof structure; on the contrary, all the evidence indicates a considerable improvement in roof life.

L. A. Deesz: Dr. Bradley's paper is very interesting. I think one of the things we are all interested in is the life of open hearth roofs.

At the Republic Steel Corporation in Youngstown, we have been doing a good deal of work on roof control, not the type of which Mr. Bradley speaks. It seems to me that one of the things that vitally affects the life of roofs is the heating-up period. We have taken probably seventy-five records with recording instruments, starting from the time that the fuel is put on

the furnace until the furnace is ready to go into operation. We have tried to plot these against a more or less theoretical curve.

I think Mr. Bradley gave a critical point of about 1500, didn't you?

M. J. Bradley: Yes. The original quartz structure of the brick changes over into the tridymite modification in the neighborhood of 1598° F.

L. A. Deesz: There is also one at about 325 degrees F. There you will find that if you don't hold the roof properly— at least we have found it so—you are liable to spall it off and may lose the equivalent from 15 to 25 heats. It just spalls off and breaks off if you are not careful.

We tried to devise some sort of instrument with a cam drive that would take and bring the heat up more or less in proportion to the theoretical curve. It is all right after the furnace is up to have temperature control on the roof. However, there is another thing that I have never been convinced of yet in temperature control. If you take your flame temperature throughout the furnaces, different types, different kinds of furnaces, different fuels on the furnace, you will find the flame temperature changes throughout the length of your furnace. It changes also due to the first helper's operation. If he has too much fuel he is liable to choke his flame down. If he gets a long flame the temperature is way out near the outgoing ends. If he has a short flame it moves up toward the incoming port. Consequently there is a movement of temperature backward and forward. It seems to me that one-position control does not give you what you are actually looking for.

There is another thing. In the illustration which Mr. Bradley has given us here, the brick on the inside of the furnace is at a very high temperature. That at the outside is at relatively low temperature. As your temperature changes inside of your furnace, your cristobalite tridymite zone in between moves upward and downward, depending upon the furnace temperatures. There is a tendency therefore, for a movement of this zone or plane through the expansion periods or critical points during all different kinds and types of heats that are made as the furnace temperature rises or lowers during furnace operation.

How this is to be handled, I think is something yet in the future. Certainly roof temperature control is coming, because all corporations are demanding longer roof life, but I think these are some of the things that yet haven't been considered.

M. J. Bradley: It is important to dry out and to heat up a new furnace slowly in order to permit the brick work to change over into its stable modification. We believe this is recognized generally and explains why new furnaces are usually warmed up with small wood fires. The control limit temperature is usually set much lower during the seasoning stage on a new furnace than it is after the brickwork is seasoned.

The flame temperature, from the two ends of the furnace will be the same provided the regenerated air for combustion is the same on the two ends of the furnace and the air-fuel ratio is maintained constant. Under these conditions, the shifting in heat head in the furnace is due to unequal draft conditions on the two ends. If the furnace pressure is maintained automatically and the regenerative cycle kept balanced by reversing automatically by the temperature difference method, one position in the center of the furnace roof does have an analogous relationship to the two ends of the furnace. This position, under balanced conditions, can be used as a relative guide for roof temperature control. It has been realized that pressure, combustion, and furnace temperatures are dependent very much upon each other. Any change in one condition has a decided influence on the others. This is the chief reason for the development of a system of control in which all these factors bearing on furnace operation are taken into consideration. Roof temperature limit control alone will not prevent the shifting of the heat head in the furnace; this can be controlled, however, by stabilizing pressure and combustion conditions.

The present tendency, in open hearth operation, is to maintain stabilized conditions to prevent extremes in temperature variations which cause the silica structure to be changed from one modification to another and thus lessens the strains and destruction of furnace roofs.

Chairman Carter: That is very fine. Thank you for your discussion.

Is there anyone else who is using a temperature controlled roof?

E. W. Hill: We have been using fuel control on one end, at times, two furnaces since last November. An L & N thermotube, mounted on the back buckstaves, is sighted through a hole in the backwall, on the inside surface of the roof. When the roof temperature reaches what we feel is a destructive one, the fuel is automatically shut off by a contact made in a Micromax controller relaying an impulse to a motor operated butterfly valve. When the roof temperature drops fifty degrees, another contact opens the valve.

Last spring we experimented with two thermotubes sighted on the ends of the main body roof. By means of a relay, the temperature of the outgoing port controlled the fuel input. The results obtained were not sufficiently superior to those of the single tube installation, to justify the additional equipment required, so we are confining our present activities to the one tube applications.

In all cases, we have had an appreciable increase in roof life, with a pleasing reduction in fuel.

L. A. Deesz: On the location of these thermocouples and so on, I don't know how Mr. Bradley is putting them in now, but if you try to put them inside of the brick and then the brick spalls off and gradually gets thinner and thinner and approaches the thermocouple, how do you know what temperature you have?

Another thing—If we put in an optical, how do we know it isn't going to get slagged over? How do we know the gases are giving us the proper temperatures. If we put in a type that is held in with a blast furnace tuyere for fire and protection then the thermocouple is placed down inside and the relative temperature taken? Since water is passed through the tuyere all

the time and that the temperature of your tuyere is always the same? The relative temperature of the tuyere fire and combination will change due to different quantities of water passing through as the plant pressure vary and also may change due to seasonal changes of temperature of the supply water.

Those are the things I would like to have answered.

Chairman Carter: Mr. McCutcheon, do you have temperature control down in Ashland—roof control?

K. C. McCutcheon: No temperature control of the roof, no.

Mr. Chairman, I would say that most operating men are certainly interested in the results obtained with the application of control, whatever the method. As it has been so aptly put there are numerous methods. Some of them are aimed at controlling roof temperatures and some of them are aimed at controlling operation temperatures. In other words, some have to do with the temperature of the charge in the furnace and not with the maintenance of roof temperature.

Whatever they are, naturally the question we want answered is: What results do you get with them? I don't think we can arrive at any conclusion by arguing about the different methods, except in the light of the results obtained by them. I am certain if we attempt to control the roof temperature and overlook its effect on the bath temperature, we will find lots of objections. On the contrary, I am satisfied, if we deal purely with bath temperatures and overlook the effect on roof temperatures there will be plenty of objections. What we really require is a good workable combination of all these ideas which will accomplish the ends desired, which are low B.t.u. consumption, high rate of production, low roof and furnace repair cost.

M. J. Conway: We do not have roof temperature control, but we do have a pyrometric temperature record of the under insulation temperature both on the furnace end walls and roof.

Our experience shows that just so long as we can burn the roof and still have roof temperature control installed that we really do not have control. Roof temperature records, however, do assist the helper in protecting the roof of the furnace, and these we have provided. We are not entirely sold from a purely control standpoint with present installation and design practice of open hearth roof control.

Gilbert Soler: I think we are all trying to obtain closer control of our furnaces. We are interested not only in roof temperature control but also control in general.

We charge a certain amount of raw material into the furnace; limestone, pig iron, and scrap of a certain size and physical condition, and of a certain analysis. The melt-down carbon and iron oxide in the slag are influenced by such factors as time of melting, degree of oxidation of the furnace gases, and temperature. We would like to control conditions during the melt-down period so that practice could be duplicated from heat to heat. This would include quite a few different types of control.

K. C. McCutcheon: I think the last remark of Mr. Soler's is putting too much up to the control. Without consideration to the charge, I do not see how you can duplicate conditions from heat to heat with a temperature control. I think that chart Mr. Bradley put on the screen showed very clearly that when the charging conditions were changed the heat in-put and control conditions changed. In other words, it was shown in the second heat that the furnace was charged and brought up to the same temperature as the first heat. Then they put in a charge of cold pig iron and it changed entirely the condition of the furnace. A maximum temperature control can't help that at all. I think the charge considering the amount of the various raw materials and when they go in, certainly will affect our ability to use an automatic control, and must be taken into consideration in setting the control points.

Gilbert Soler: Probably I gave the wrong impression. I was speaking of control in general. Such results cannot be attained by any single control factor such as roof temperature control but probably by a combination of such factors.

M. J. Bradley: We confined our remarks purposely to one method of measuring and limiting the soaking temperatures in open hearth roofs. We have learned through experience the futility of becoming involved in an extensive argument on any one phase of open hearth control because of the innumerable factors involved. We realize that many factors enter the picture and their influences should be taken into consideration when discussing any one factor by itself. We believe we explained how the brick is built up periodically with carbofrax cement, to keep in step with the gradual wearing away of the roof structure, so that relative temperature reading may be obtained throughout the roof life. The installation of the thermotube has been engineered so that there is no possibility of it slagging over or giving erroneous results. We discussed, purposely, one heat where the first helper had to fight in order to get the heat out. There are occasionally some heats encountered where the first helper has to sacrifice some roof life in order to get the heat ready for tapping. Provision is made to make the control inoperative under such conditions if the first helper desires. However, in most cases, we find the first helper prefers to keep the control operating to assist him.

We have developed different types of sighting blocks and worked on many other methods of open hearth roof controls but hesitate to intrude on your time by discussing them now. We believe, however, that this discussion will do much to advance the problem and we wish to thank Mr. Deesz and the others for their helpful comments.

▲ ▲ ▲ ITEMS OF INTEREST ▲ ▲ ▲

Lee H. Mandeville, an active member of the A. I. & S. E. E., and formerly associated with the Universal Steel Company, Bridgeville, Pa., at which plant he was engaged in research work in connection with the processing of alloy and stainless steels, has resigned from this company to become the chief engineer of the Continental Steel Corporation, Kokomo, Ind.

In his new capacity Mr. Mandeville will have general supervision of plant maintenance, operation of all plant auxiliaries, and engineering new projects in connection with this plant as well as the Canton, Ohio, and Indianapolis, Ind. plants of the corporation.

▲

W. J. Phillips, an active member of the A. I. & S. E. E., has been appointed plant engineer for the Calumet Steel Company, Chicago Heights, Ill.

Mr. Phillips was for eighteen years with Bethlehem Steel Company at Bethlehem, Pa., and from 1931 to 1935 was assistant chief engineer of the Youngstown district of the Republic Steel Corporation, and just prior to his recent appointment was associated with the Continental Roll and Steel Foundry Company as a special engineer.

▲

John L. Young, an associate member of the A. I. & S. E. E., until recently associated with the Timken Roller Bearing Company, Canton, Ohio, as the assistant general manager of the industrial division, has resigned to join the United Engineering and Foundry Company, Pittsburgh. Mr. Young will be a member of the United service engineering department which division is set up to assure effective application of United rolling mills and auxiliary machines in the steel mills and finishing departments. Consequently, Mr. Young will take an active interest in the development, design, production, and servicing of all types of United equipment. Graduating from the University of Indiana in 1921 with a degree of Bachelor of Science, Mr. Young entered the employment of the Timken Roller Bearing Company soon thereafter as an engineer.

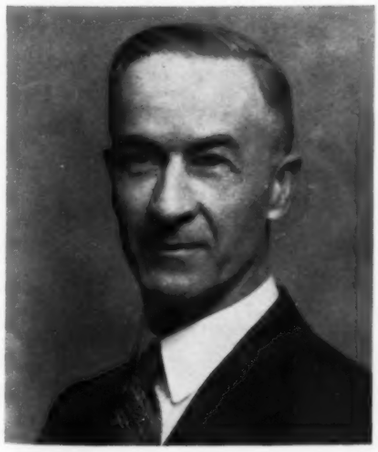
In August 1922 he was transferred to the sales department with headquarters in Chicago to cover the mining fields of the middle west in the development of the mine car bearing.

Early in 1923 an industrial office was opened in St. Louis and he was sent there as sales engineer still specializing in mine cars.

In January 1924 he was transferred to Pittsburgh to open an industrial office. Along with the mine car work in Pittsburgh he was also in charge of the general industrial applications in that territory which led up to the development of the use of anti-friction bearings in machinery for the oil fields, and in 1926 when the 4-High hot and cold strip mills were being developed in and around the Pittsburgh district he aided in the development of tapered roller bearings to the first mills of this sort at the Columbia Steel Company, Butler, Pa., and the Allegheny Steel Company, Brackenridge, Pa.

This development continued until November 1929 when he was transferred to the Canton, Ohio plant for special training in the steel plant and metallurgical division.

In June, 1931 he returned to Pittsburgh as development engineer specializing in steel mill equipment, and in January 1932 became district manager of the Pittsburgh office and remained there until November 1934 at which time he was transferred to Canton, Ohio as assistant general manager of the industrial division.



LEE H. MANDEVILLE

JOHN L. YOUNG

S. S. MARSHALL

C. L. McGRANAHAN

In preparation for a proposed program of new mill construction and plant expansion the Jones & Laughlin Steel Corporation has made several changes in its operating staff, it was announced February 8.

S. S. Marshall has been appointed assistant general manager. Since 1929 he has been general superintendent of the Pittsburgh Works. Mr. Marshall's entire steel business experience has been with Jones & Laughlin. He started in 1903 as a stake driver with the Civil Engineering department and advanced successively as master mechanic; assistant superintendent, Eliza Works; assistant superintendent, South Side Works; general superintendent, South Side Works; and general superintendent, Pittsburgh Works.

▲

H. D. Stark, who has been appointed general superintendent of Pittsburgh Works, has been, since 1929, assistant general superintendent of the Pittsburgh Works. He went to work for Jones & Laughlin in 1899 as a blue-print boy in the engineering department of the South Side Works and has successively occupied positions as superintendent of shops, assistant superintendent of steel works, superintendent of steel works, assistant general superintendent of the South Side Works and assistant general superintendent of the Pittsburgh Works.

▲

Charles L. McGranahan, an active member of the A. I. & S. E. E., has been engaged as assistant general superintendent of Pittsburgh Works to supervise the construction of the new $25,000,000 strip and sheet mill and to operate it when completed. For the past four years Mr. McGranahan has been with the Inland Steel Company, of Chicago, as Superintendent of the strip and sheet mill department. Prior to that, he had been with the American Sheet and Tin Plate Company for 16 years in Pittsburgh, Pa., and Gary, Ind.

▲

J. C. Murray, who has been appointed assistant general superintendent of the Pittsburgh Works, has been since 1929, assistant general superintendent in charge of the North Side Works. He is president of

H. D. STARK

J. C. MURRAY

W. H. HOLT

J. H. CAYLOR

the Eastern States Blast Furnace & Coke Oven Association and also an active member of the A. I. & S. E. E. Mr. Murray joined the J & L organization in 1915 as a clerk in the Eliza blast furnace department.

▲

J. H. Caylor, who has been appointed assistant general superintendent of the Pittsburgh Works, has been, since 1924, superintendent of rolling mills at South Side Works. He entered the steel business in 1907 with Carnegie Steel Company and subsequently was with Cambria Steel Co., Johnstown, Pa., and Donner Steel Co., Buffalo, N. Y., coming to Jones & Laughlin in 1924.

▲

W. J. Ballantyne has been appointed superintendent of steel works and blooming mills at Pittsburgh Works. He has been, since 1924, superintendent of open hearth and bessemer department, South Side Works. Prior to joining Jones & Laughlin he had been with the Illinois Steel Company at Chicago, from 1912 to 1924.

W. H. Holt, who has been appointed assistant superintendent of the steel works and blooming mills, Pittsburgh Works, has been superintendent of the blooming mills, South Side Works, since 1928. In 1916 he was employed in the engineering department of the Pennsylvania Railroad. He advanced through various positions until 1923 when he came to Jones & Laughlin as assistant superintendent of the Labor Department of the South Side Works.

▲

James D. Stewart, who has been appointed superintendent of rolling mills, Pittsburgh Works, has been, since 1930, assistant superintendent of rolling mills. He started in the engineering department of the Monongahela River Consolidated Coal & Coke Co., and was successively with the Bessemer & Lake Erie Railroad, and the Pennsylvania Railroad until 1923 when he joined Jones & Laughlin as assistant superintendent of the No. 14 Mill, South Side Works.

(Please turn to page 36)

W. J. BALLANTYNE

J. D. STEWART

FUSES MADE TO PROTECT • NOT TO BLOW

GET THE FACTS —

"Recently, as a matter of courtesy to a friendly salesman, we agreed to check the performance of some 'ordinary' 60 ampere 600 volt fuses on a circuit controlling a 30 ampere motor. A complaint came in immediately from the maintenance electrician that the fuses were popping out on the starting current. In the same spot BUSS Super-Lag fuses had protected for several years without PERMITTING A SINGLE PRODUCTION DELAY due to their not meeting the starting requirements of the motor."

So says The Electrician of the Cherokee St. Plant, International Shoe Co., St. Louis.

Like other alert maintenance men he is vitally interested in any item that will help free operating schedules of needless interruptions.

Executives interested in plant operation sometimes overlook the inexpensive fuse when they are checking operating schedules—yet "Fuses made to protect —not to blow" offer them a practical way to . . .

...prevent the RECURRING SHUTDOWNS caused by NEEDLESS BLOWS!

After all, since we are dealing with money-waste isn't it a matter well worth executive investigation to determine just how senseless and unnecessary shutdowns can be eliminated—just how fuses are made to protect—not to blow—just how others have profited handsomely by investigating . . .

WHY BUSS FUSES DON'T BLOW NEEDLESSLY

10 Features

in the design of the FUSE-CASE help make it possible and . . . .

The Super-Lag

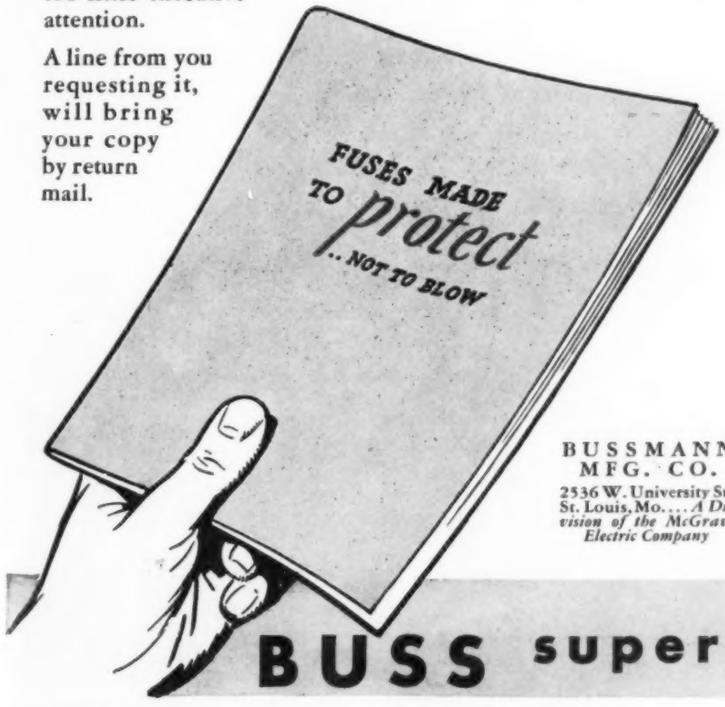
development in the FUSE LINK completes the job.

GET THE FACTS

Even though you may be but remotely interested in your company's earnings . . . you will obtain enough new information from this booklet to make your suggestions on prevention of needless shutdowns a valuable contribution.

It is replete with refreshing facts on a subject receiving far too little executive attention.

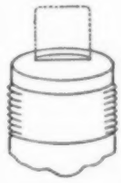
A line from you requesting it, will bring your copy by return mail.



BUSSMANN MFG. CO.
2536 W. University St.
St. Louis, Mo. . . . . *A Division of the McGraw Electric Company*

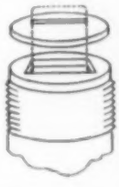
Check this "BLOW-PROOFING" idea on a BUSS Fuse

It stands to reason that a link torn or badly strained, is not going to carry its rated amperage—therefore on BUSS fuses the link is held against twisting when the fuse is renewed.



Note that one end of the link is held snugly in a slot. It can't twist as the cap is tightened.

The other end is locked by a slot in the washer against the square opening in the fuse case.



You don't have to be EXTRA careful with a BUSS fuse—for the design automatically safeguards the link against injury—just as it automatically safeguards the user against needless blows and senseless shutdowns.

Executives who have the "feel of the plant"—who like things mechanical—will "get a kick" out of observing the nicety with which each part of the BUSS design is fitted to its job of making a fuse to protect—not to blow.

Why not investigate.

BUSS superlag FUSES

I. Lamont Hughes, Executive Vice President of the Carnegie-Illinois Steel Corporation, was made President of the Engineers' Society of Western Pennsylvania at an election held recently.

The Engineers' Society of Western Pennsylvania was organized on January 6, 1880, for the purpoes of interchanging ideas and developing a closer acquaintship of engineers in the Pittsburgh District.

Over a period of 56 years, the Society and its members have contributed materially to the progress and well-being of the Pittsburgh industrial district.

▲

Edwin T. Warren has been appointed superintendent of blast furnaces, Edgar Thomson Works, Carnegie-Illinois Steel Corporation to succeed F. H. N. Gerwig now on leave of absence.

Mr. Warren began his business career with the Baltimore Warehouse of the Carnegie Steel Company in July, 1915, was transferred to the Homestead Steel Works engineering department in September, 1915, until February, 1918, when he enlisted in the United States Army and served 12 months overseas in the Engineering Corps.

Upon being discharged from the army, he returned to the metallurgical department of the Homestead Steel Works in June, 1919, and was made assistant superintendent of open hearth No. 3, February, 1925, was promoted to assistant superintendent of Carrie Furnaces, May 1, 1928, to date.

Mr. Warren is a graduate of the New Rochelle, New York, High School, and Worcester Polytechnic Institute, Worcester, Mass., class of 1915, with the degree of B. S. in Civil Engineering and is a member of the Eastern States Blast Furnace and Coke Oven Association.

Douglas P. Steward has been appointed chief engineer, Carnegie-Illinois Steel Corporation, Lorain District.

Mr. Steward was first employed by the Lorain Steel Company in 1923 as draftsman. His services have been continuous and since 1934, he has been assistant general superintendent, to date.

Mr. Steward is a graduate of Tufts College, Massachusetts.

▲

Roy H. Noderer has been appointed manager of the metallurgical department, Carnegie-Illinois Steel Corporation, Lorain District.

Mr. Noderer attended Oberlin College, Oberlin, Ohio. He was employed in 1903 by National Tube Company, Lorain, Ohio, in their chemical laboratory, coming to the Lorain Steel Company, Johnstown, Pa., as Chief Chemist in 1910, until 1926, when he was promoted to metallurgist, in which capacity he served until his present appointment.

Mr. Noderer is a member of the American Society of Testing Materials; American Welding Society; American Society for Metals; and American Foundrymen's Association.

▲

Thomas J. McLoughlin, as announced by the Carnegie-Illinois Steel Corporation, has been appointed assistant to W. S. Oberg, manager of operations for the Pittsburgh district.

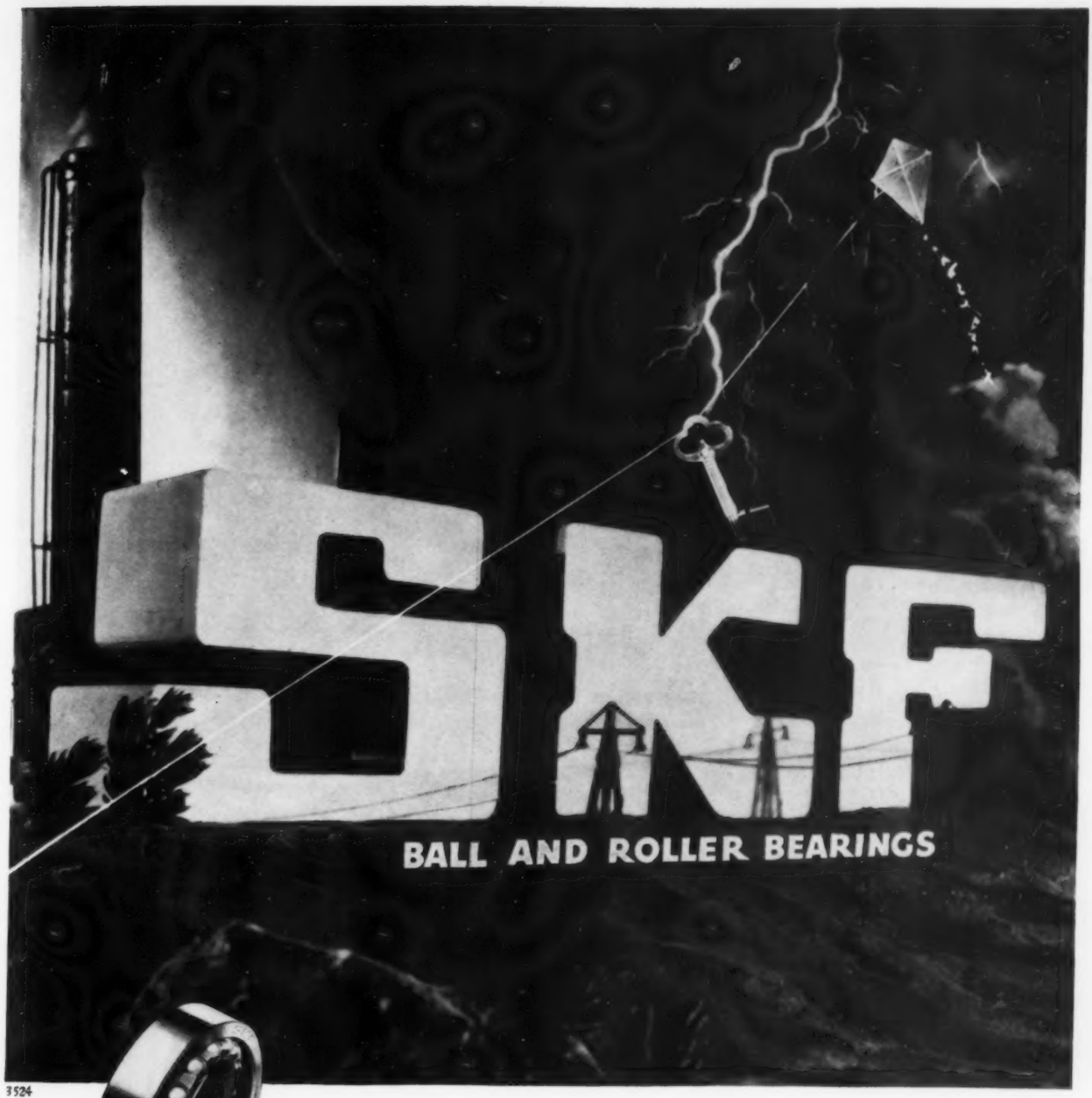
Mr. McLoughlin's service with the United States Steel Corporation began at the Duquesne Steel Works of the Carnegie Steel Company in 1913 as an engineer apprentice. His services have been continuous, and he has been fuel engineer at the Duquesne Works since 1924.

(Please turn to page 38)

I. LAMONT HUGHES

EDWIN T. WARREN

THOMAS J. McLOUGHLIN



SYMBOLS OF PIONEERING AND PERFORMANCE ...FRANKLIN'S KEY AND AN SKF BEARING

● When Franklin sought knowledge of the mystery-element called Electricity, he sent his immortal kite into the Heavens, which he believed to be its Source.

We like to cherish the fact that when the electrical engineers of our own day sensed the need for anti-friction bearings to improve the performance of electric motors and generators, they too came to a world-recognized Source. They came to SKF. The result today is that practically all outstanding manufacturers of rotating electrical apparatus use SKF Anti-Friction Bearings in their equipment. SKF Industries, Inc., Front Street and Erie Avenue, Philadelphia, Pa.

The mark, "SKF-Equipped," on an electric motor or generator or in a catalog featuring such apparatus is an assuring symbol of quality and performance that is recognized throughout the world.

ROY H. NODERER

FRANK L. GIBBONS

PAUL F. VOIGHT, JR.

He graduated from the Stevens Institute of Technology with the degree of Mechanical Engineer.

He is a member of the American Iron and Steel Institute and is a Director of the Engineers' Society of Western Pennsylvania.

▲

Paul F. Voight, Jr., has been appointed manager of the newly created stainless steel division of the Carnegie-Illinois Steel Corporation with offices in the Carnegie Building, Pittsburgh.

He will also supervise the production and sale of stainless steel made by other Subsidiary Companies of the United States Steel Corporation.

Mr. Voight was formerly Vice President of the Allegheny Steel Company and has been intimately connected with the commercial development of stainless steel, which has come into such general use during the past twelve years.

▲

Frank L. Gibbons has been appointed manager of sales of the new alloy division of the Carnegie-Illinois Steel Corporation with headquarters at 208 South LaSalle Street, Chicago.

Mr. Gibbons was formerly Vice President of the Timken Steel & Tube Company, being previously associated with Republic Steel Corporation and Central Alloy Steel Corporation, and has specialized in the development and sale of alloy steels for over twenty years.

▲

Charles B. Getsinger, as announced by the Carnegie-Illinois Steel Corporation, has had his title changed from that of director of fuel and power for the corporation to that of manager of raw materials, fuel, and power for the Pittsburgh district.

▲

H. L. Wilcox, Electric Controller and Manufacturing Company, has been appointed assistant chief engineer of this company to succeed the late J. H. Hall.

R. C. Brower, Secretary-Treasurer of the Timken Roller Bearing Company, has been elected a director of the company to fill the vacancy created by the recent death of Mr. J. G. Obermier.

Mr. Brower joined the Timken organization in 1916 as assistant manager of The Timken Service & Sales Company, later becoming Manager. He was then appointed assistant secretary-treasurer of The Timken Roller Bearing Company, being made Secretary-Treasurer of the Company in 1930.

▲

S. C. Partridge, of the Timken Roller Bearing Company, has been appointed assistant general manager of the industrial division, with headquarters in Canton. Mr. Partridge was graduated from the engineering school of McGill University in 1925, spending the next four years in the field on engineering work for the government. He joined the Timken organization in 1925, working first in the shop and then in the engineering department, where he secured a thorough training in the manufacture of Timken Bearings as well as their application to all types of equipment.

In 1926 Mr. Partridge was sent to Buffalo, where he had charge of the Timken industrial district office for the next two years, going to Toronto in 1928, where he was made manager of The Timken Roller Bearing Company, Limited, in charge of both automotive and industrial sales. His next advance was to the Detroit Office of the Company, where he assisted Mr. E. W. Austin, General Sales Manager, Automotive Division, which position he has filled until his present appointment as assistant to Mr. W. B. Moore, general manager of the industrial Division of The Timken Roller Bearing Company.

▲

F. B. Yates, Timken Roller Bearing Company, has been appointed manager of the New York District Office, in charge of industrial sales. Mr. Yates joined the Timken organization in 1926 after receiving his degree in mechanical engineering from the Sheffield

(Please turn to page 41)

The WEAN CONTINUOUS STRIP PICKLER

The Wean Continuous Pickling Unit consists of machinery especially designed and arranged to produce most efficiently the finest quality of pickled material. In addition, higher speeds are possible and greater tonnage can be procured.

THE CONTINUOUS PICKLING UNIT CAN BE FURNISHED COMPLETE FROM THE HANDLING OF THE HOT STRIP COIL TO THE FINISHED PRODUCT.

The WEAN ENGINEERING CO., Inc.

WARREN, OHIO

Associated Companies:
LEE WILSON ENGINEERING CO.
THE McKAY MACHINE CO.
FLINN & DREFFEIN CO.

OUR PRODUCTS

AUTOMATIC FEEDING AND CATCHING TABLES.
CONTINUOUS PACK AND PAIR HEATING FURNACES.
WHEELABRATOR ABRASIVE CLEANING EQUIPMENT.
SHEET GALVANIZING EQUIPMENT.
AUTOMATIC TINNING EQUIPMENT.
AUTOMATIC DOUBLERS.
NORMALIZING FURNACES.
McKAY LEVELLERS AND PROCESSING UNITS.
CONTINUOUS STRIP PICKLING EQUIPMENT including UNCOILERS, UP-CUT SHEARS, STITCHING MACHINES, PINCH ROLL UNITS, RECOILERS, DRYING MACHINES, PICKLING TANKS, and AUXILIARY EQUIPMENT.
SCRUBBING, LEVELING OILING and MACHINES for FLAT PRODUCTS.
WILSON VERTICAL TUBE TYPE ANNEALING FURNACES.

Announcing . . .

THE ACQUISITION OF THE WOOSTER, OHIO PLANT

OF THE MACKINTOSH-HEMPHILL COMPANY

BY

United Engineering and Foundry Company

•

UNITED Engineering and Foundry Company is pleased to announce they have acquired by outright purchase, February 5th, (1) *the manufacturing plant* at Wooster, Ohio of Mackintosh-Hemphill Company, and (2) *all drawings and patterns* of that company used in the manufacture of rolling mill equipment.

Replacement parts, both rough and machined castings, and complete mills and machines which the Mackintosh-Hemphill Company designed and built are now offered by UNITED; such equipment includes:

Universal Mills

3-High Balanced Sheet Mills designed for application of automatic tables and continuous furnaces

Cut Mill Pinions

Hot Strip Mills for modified tonnages

Precision Thrust Bearings for rod and merchant bar mills,

And other rolling mill equipment

The Wooster, Ohio plant will be an active production unit of UNITED. It covers eleven acres with machine shop, forge shop, and fitting and erecting floor. The heavy machinery section is entirely modernized. Single pieces up to about 300,000 pounds may be handled and the largest rolling mill machinery may be assembled.

The plant, one hundred and fifty miles northwest of Pittsburgh, is well situated to serve the steel districts of Chicago, Detroit, Ohio and Pittsburgh.

A direct company telephone connects UNITED'S plants at Wooster, Youngstown, Canton, Vandergrift, Pittsburgh and the general offices at Pittsburgh.

Scientific School of Yale University, spending his first year with the company in the special training course which covered both shop and engineering practice in bearing manufacture and application. After some time in the Chicago district office, Mr. Yates was transferred to the New York District Office in 1928, and now takes charge of that office, where he will continue to specialize in the industrial applications of Timken Bearings.

▲

R. W. Powers, a graduate from the engineering college of the University of Michigan in 1931, has been transferred from the Canton engineering department of the Company to the New York District Office as sales engineer, assisting Mr. Yates.

▲

S. C. Merrill, Timken Roller Bearing Company, has been appointed to the position of eastern district manager of the automotive division, with headquarters in Detroit.

Mr. Merrill, a graduate mechanical engineer, Columbia University, 1917, spent several years in the New York territory in production and sales work before joining the Timken organization in 1924. Since then he has been manager of the New York District Office of The Timken Roller Bearing Company and during the past year has been handling automotive applications as well as those in the industrial field. His broad industrial and automotive experience gives him the necessary background to handle the specialized problems involved in the automotive field.

▲

S. D. Williams, Timken Steel & Tube Company, has been appointed to the position of director of sales, with headquarters in Canton, Ohio. Mr. Williams has been connected with the Timken organization since 1926, starting as metallurgical sales engineer, having been made manager of tube sales in 1935, after having served as assistant director of sales for several years.

Mr. Williams has been active in the development of special steels to meet the needs of the trade, his metallurgical training and wide practical experience and understanding of operating conditions enabling him to appreciate the problems of users of Timken seamless tubing and Timken alloy steels.

▲

Thos. Holloway, formerly Gear Consultant of the United Engineering and Foundry Company, and also Sales Engineer of the Farrel-Birmingham Co., at Buffalo, New York, has been placed in charge of Sales and Design of Gears and Gear Units for the rolling mill industry of the Maag Gear manufactured by the General Machinery Corporation of Hamilton, Ohio. Mr. Holloway will have his headquarters in Pittsburgh at 710 Grant Building. The Maag Gear is available from 3″ to 45′ diameter and from 3″ face to 72″ face in either spur, helical, or double helical type of teeth.

▲

Neil Currie, Jr., for the last six years manager of the General Electric Company's Philadelphia Works, was made manager of its Fort Wayne Works effective February 1st, it was announced recently by W. R. Burrows, vice president in charge of manufacturing. Mr. Currie succeeds Walter S. Goll who, although retiring as manager after 38 years of service, will continue with the company and will be available for special assignments. R. V. Good, previously assistant manager at Philadelphia, was appointed manager to succeed Mr. Currie.

▲

L. H. McClure has been appointed sales manager of the Colt-Noark Division of the Colt's Patent Fire Arms Manufacturing Company, Hartford, Conn.

A graduate of Trinity College in 1912, Mr. McClure has been associated with the Colt company for the past eighteen years.

▲

Lloyd Jones, vice president of Continental Roll & Steel Foundry Co., Pittsburgh, Pa., who has been ill for the last few months, has resigned. He will remain with the Continental company in a consulting capacity. Mr. Jones was formerly with United Engineering & Foundry Co., and before going with the Continental company, he was connected with the E. W. Bliss Co., Salem, Ohio.

▲

George Dandrow has been appointed manager of the New York District, Power Products and Industrial Division of the Johns-Manville Sales Corporation with headquarters in New York City.

Mr. Dandrow joined the Johns-Manville organization in 1922 directly following his graduation from the Massachusetts Institute of Technology where he will be remembered as the inter-collegiate hammer throwing champion and weight thrower on the 1920 American Olympic team. After five years in Johns-Manville's Boston branch, Mr. Dandrow joined the general engineering staff at Headquarters in New York and for the last few years has been assistant manager of the New York District.

WITH THE MANUFACTURERS

Hagan Corporation of Pittsburgh announces the appointment of Hendrie & Bolthoff Manufacturing & Supply Company of Denver, Colorado, as its representative for the handling of combustion control equipment and as the representative of Hall Laboratories and The Buromin Company in the field of boiler water conditioning.

▲

Lukens Steel Company, Coatesville, Pa., have prepared a bulletin in which is included all the data accumulated over the past five years on approved methods of fabricating Lukens Nickel-Clad Steel. This bulletin is available for those who requested it.

▲

Leeds and Northrup Company, Philadelphia, Pa., have just issued a booklet, which is available on request, in which is described reliable electrical equipment which measures smoke density at the stack, indicates and records it wherever needed, and signals major changes if desired.

▲

A special line of transformers and reactors for use with the new mercury vapor (high lighting efficiency) lamps has been developed and is being marketed by the Jefferson Electric Company, Bellwood, Illinois. These transformers provide the proper voltage for the lamps and keep the current low during the initial starting period. They are designed to give full rated capacity to the lamp and to operate continuously with low temperature rise.

The line includes types for wall mounting, ceiling suspension and a weather-proof model assembled in a drawn single piece cylindrical housing. A special convenience feature is the snap-on self-locking plug and jack connections which provide quick changes of primary transformer tap to match the power supply line voltage.

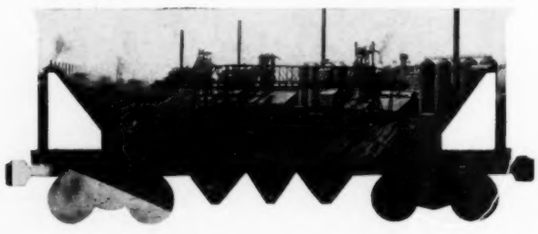
The same units are also supplied in core and coil type (without casings) for mounting directly in the lamp fixture.

OBITUARIES

Fred C. Deming, Manager of Sales for the Carnegie-Illinois Steel Corporation at Buffalo, New York, died suddenly at his residence at Wanakah, New York, on January 17. Mr. Deming was born in Buffalo, New York, on March 5, 1868. He attended Public Schools, and State Normal School of Buffalo. He is survived by his widow, two daughters, and three grandchildren.

Mr. Deming's service with the United States Steel Corporation began in 1892 as a salesman with the Buffalo Sales Office of the Carnegie Steel Company. He was promoted to Assistant Manager of Sales, in 1901, and was made Manager of Sales, Buffalo Office, in August, 1911, serving in that capacity until his death.

▲

James W. McClure, Assistant to the Auditor of the Carnegie-Illinois Steel Corp., died of pneumonia at his residence, Colonial Apartments, Beaver, Pa., Thursday, Feb. 6, 1936. He is survived by his widow, Maude L. Seiler.

Mr. McClure was born in Canada on Sept. 29, 1889. He started his business career with the Carnegie Steel Company, Ohio Works, Youngstown, Ohio, on the 11th of July, 1907, passing to various positions until January 16, 1922, when he became secretary to I. Lamont Hughes, who was then General Superintendent of the Youngstown Works. He came to Pittsburgh as Mr. Hughes' secretary, when Mr. Hughes was promoted to Vice President of Carnegie Steel Company in 1925. He accompanied Mr. Hughes to the New York office when Mr. Hughes became Vice President of the United States Steel Corp. on June 1, 1928. He returned to Pittsburgh as a Special Engineer on Nov. 1, 1930, when Mr. Hughes was made President of the Carnegie Steel Company. He was appointed Chief of the Cost Department of the Carnegie Steel Company on Sept. 1, 1932, and Assistant to the Auditor, Carnegie-Illinois Steel Corporation, on Dec. 1, 1935.